

AUGUST 18, 1960

MACHINE

# DESIGN

A PENTON PUBLICATION - BIWEEKLY

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AUG 24 1960

TECHNOLOGY  
DEPARTMENT

## Planning The Engineering Office

Contents, Page 3



Better bearings begin here in the newly constructed laboratories of Bound Brook's Research and Development Division. Here, with new facilities and modern equipment, Bound Brook's highly specialized talents create new bearing materials, help you develop new product applications. Here, Bound Brook engineers employ unique test equipment to duplicate any conditions, service-test your bearings before they're put in production. If you want to turn your problems into new ideas, new designs, new bearing applications . . . turn to Bound Brook!

Circle 401 on Page 19

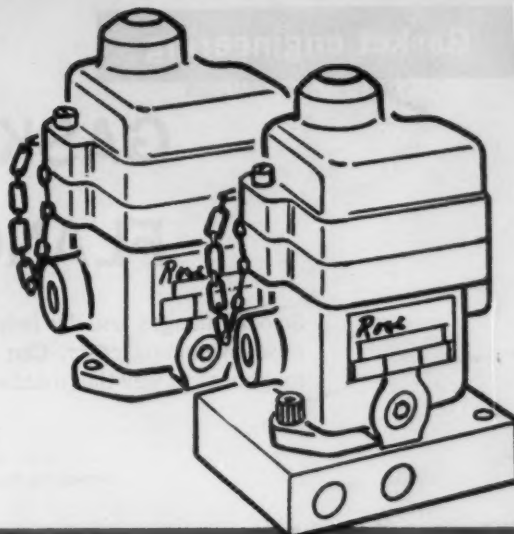
## **BOUND BROOK**

Bound Brook Oil-less Bearing Co., Bound Brook, N. J.  
Pioneer in Powder Metallurgy Bearings and Parts.  
*Plants at Bound Brook, N.J. and Sturgis, Mich.*



# The **Ross** PACER gives you 56 new solenoid air valves

The Ross PACER is a fine new solenoid valve in the  $\frac{1}{8}$ " and  $\frac{1}{4}$ " size range that gives a full  $\frac{1}{2}$ " flow capacity yet uses only 7 watts of holding power. The PACER is built for especially long life yet is priced surprisingly low. Capable of 1000 cycles per minute and more, is JIC, and very light and compact. And if you're interested in large valves the PACER has a second identity, that of a pilot section to actuate any valve of the Ross Skyline series. It will operate any of these valves at top speed and with low power consumption.



As well as  
being a  
complete  
new valve

... PACER is  
also a new  
pilot section  
in the Ross  
Skyline valve  
series...

## COMPLETE PACER VALVES

STRAIGHTWAY, N/C  
3-WAY, N/C  
4-WAY

## PIPE SIZES

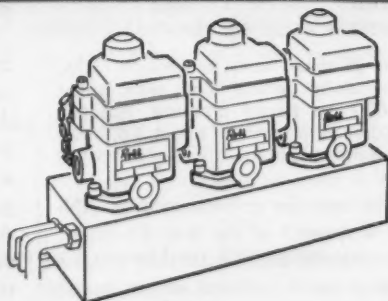
	$\frac{1}{8}$ "	$\frac{1}{4}$ "	$\frac{3}{8}$ "	$\frac{1}{2}$ "	$\frac{3}{4}$ "	1"	1 $\frac{1}{4}$ "
STRAIGHTWAY, N/C	✓	✓					
3-WAY, N/C	✓	✓					
4-WAY	✓	✓					

## SKYLINE VALVES USING PACER AS ACTUATOR (HEAD)

STRAIGHTWAY, N/C  
STRAIGHTWAY, N/O  
3-WAY, N/C INLINE MT.  
3-WAY N/O, INLINE MT.  
3-WAY, N/C, BASE MT.  
3-WAY, N/O, BASE MT.  
4-WAY, INLINE MT.  
4-WAY, BASE MT.  
4-WAY, 5-PORT

STRAIGHTWAY, N/C		✓	✓	✓	✓	✓	✓
STRAIGHTWAY, N/O		✓	✓	✓	✓	✓	✓
3-WAY, N/C INLINE MT.		✓	✓	✓	✓	✓	✓
3-WAY N/O, INLINE MT.		✓	✓	✓	✓	✓	✓
3-WAY, N/C, BASE MT.		✓	✓	✓	✓	✓	✓
3-WAY, N/O, BASE MT.		✓	✓	✓	✓	✓	✓
4-WAY, INLINE MT.		✓	✓	✓	✓		
4-WAY, BASE MT.		✓	✓	✓	✓	✓	✓
4-WAY, 5-PORT		✓	✓	✓	✓		

New PACER  
manifolds to  
save piping  
and wiring

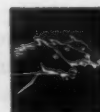


Ross manifolds provide a compact and economical method of multiple mounting PACER valves. One air supply line and one electrical conduit can serve all PACER valves. Manifolds are available in two and three stations.



# **Ross** OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.



# GASKET SEALS VS. FLANGE FINISH

Smooth flanges usually help simplify gasket problems . . . but they raise machining costs. Can a gasket material compensate for flange roughness so well that machining costs can be reduced?

E. M. SMOLEY

Research Physicist

Armstrong Research and Development Center

**H**ow smooth do flange surfaces in gasketed assemblies have to be? Is there a gasket that will seal so efficiently that reductions in flange surface smoothness might be practical?

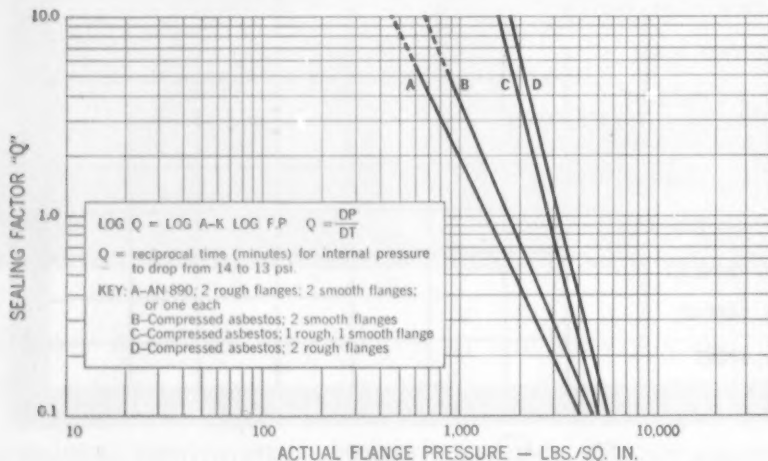
To answer these questions, extensive tests were conducted at the Armstrong Research and Development Center, using rough (3000 micro-inch) and smooth (5 micro-inch) flange finishes.

Two different gasket materials were compared: one, a standard grade of

air leakage tester developed by Armstrong engineers.

Many individual tests were run, using two smooth flanges, two rough flanges, or one of each. The results are condensed on the chart below.

The curves show that AN-890 has far better sealability with either rough or smooth flanges — or one of each — than the compressed asbestos material. Even at the relatively low flange pressure of 1000 psi, the unusual sealing ability of AN-890 is evident.



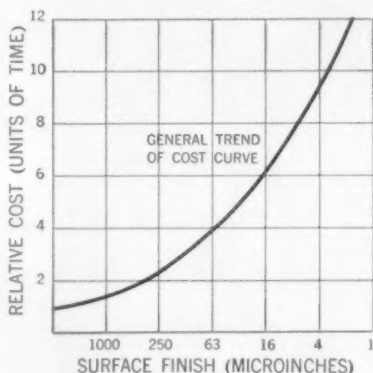
Condensed results of sealing tests on smooth (5 micro-inch) and rough (3000 micro-inch) surfaces. Sealing efficiency plotted along vertical axis, with lowest point representing best seal. Example: At 1000 psi flange pressure, Accopac AN-890 (A) has a sealing factor of about 1.8; Curve B, a factor of about 3.6; other curves are off the chart. All testing done at room temperature.

compressed asbestos; the other, Armstrong Accopac AN-890, a beater-saturated rubber-asbestos material. Both were 1/32" gauge.

In each test, air was locked in gasketed flange assemblies at an internal pressure of 14 psi. Then pressure loss was measured and recorded as a function of time by the electro-mechanical

is a more compressible material. As a result, it has unusual conformability to flange irregularities.

These tests indicate that Accopac AN-890 offers definite promise of efficient seals at higher micro-inch flange finishes. This can represent a



As micro-inch finish is reduced, machining costs climb more and more steeply. (Chart: Machine Design.)

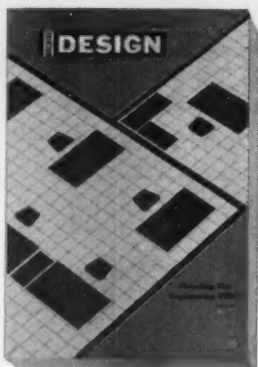
potential saving in machining costs that is well worth considering. We would be glad to discuss specific applications with you.

If you do not already have a copy of the Armstrong Gasket Design Manual, send for it today. It contains much data on the selection and design of resilient gasket materials. Address your request to Armstrong Cork Co., 7108 Dean Street, Lancaster, Penna.



## Armstrong GASKET MATERIALS

1860-1960 Beginning our second century of progress



**Front Cover:** An efficient method for laying out an engineering office on conveniently sized grid lines is represented by artist George Farnsworth in his checkerboard cover design. Logical steps for determining the best move are outlined by Robert Murdick on Page 138.

August 18, 1960

**Wire-Race Bearings . . . . . 30**

*News Report*—A unique design idea for low-friction ball and roller bearings that permits separation of the raceway from the bearing ring.

**Planning the Engineering Office . . . . . 138**

ROBERT G. MURDICK—Six logical steps: Survey existing arrangements, analyze needs, plan new layout, evaluate alternatives, implement plans, adjust new arrangements.

**Critical Speeds Simplified . . . . . 152**

F. F. FERRARY and JOHN E. NELSON—A quick method of approximating the first critical speeds of shafts having any number of concentrated loads between supports.

**Controlling Pressure . . . . . 155**

I. LEONARD KAPLAN—Details of techniques that permit control of force through control of maximum or minimum pressures in hydraulic systems.

**Thermal Stresses in Design . . . . . 160**

S. S. MANSON—Part 22: *Cumulative Fatigue Damage*—How a crack induced by nonrepetitive thermal loading propagates and affects the useful life of a part.

**Designing with Vinyls . . . . . 175**

C. W. BULKLEY—Part 3: *Forms and Applications*—Typical applications for vinyl forms produced by rolling, coating, extruding, casting, spraying, and embossing.

**Predicting Reliability . . . . . 178**

MORRIS I. KAUFMANN and ROGER A. KAUFMAN—A review of techniques currently in use, and introduction of a new concept: Relative-utility evaluation.

**Cold Heading . . . . . 185**

E. F. TAUSCHER—*Data Sheet*—How to determine the weight of parts and the amount of stock required for the head in relation to the diameter of the wire.

**Energy Conversion Processes . . . . . 189**

GEOFFREY W. WILSON—*Design Abstracts*—A progress report on developments in thermoelectric, thermionic, and photovoltaic techniques for producing electrical power.

CONTINUED NEXT PAGE



## Environment for Creativity . . . . . 137

COLIN CARMICHAEL—Editorial

## Engineering News . . . . . 6

Nuclear carrier . . . . .	6	Kort nozzle . . . . .	24
NSPE opposes Foley bill . . .	6	Fan-burner engine . . . . .	25
Mechanisms Conference . . .	8	Spacecraft APU . . . . .	25
Miniature memory . . . . .	8	Engineer at work . . . . .	26
Raysistor . . . . .	10	Plastic sheet checks welds . .	28
Nuclear aircraft . . . . .	12	Tungsten plating . . . . .	32
Plastic ammunition . . . . .	12	NASA research . . . . .	34
Democratic computers . . . .	14	Business-aircraft engine . . .	39
Metals Matters . . . . .	14	Digital system breadboard . .	41
Mark Century . . . . .	15	New strobolac . . . . .	44
Trends . . . . .	22		
Meetings and Shows . . . . .	45		
Short Courses and Symposia . .	50		

## Scanning the Field for Ideas . . . . . 146

Cam limits torque applied to follower arm—co-operative discs provide 1 millisecond flashing light—tilted teeth quickly release or lock clamp jaws—punched-card memory automatically operates potentiometers—rib on metal hose guard provides single-plane rigidity—caged cam mechanically locks shuttle contacts in position—pulse recorder simplifies evaluation of punched-tape data—gas-surrounded "contacts" complete circuit—cutter blade cuts cable to provide deceleration buffer.

## Design in Action . . . . . 167

Electronic calipers control selective grinding machine—rotatable rings register pneumatic carrier destination—air valve senses load changes in pneumatic leveler—double servo system controls mixing ratio and flow rate—one-side accessibility adapts compressor to tight corners.

## Tips and Techniques

Reproduction prints . . . . .	145	Triangle transparency . . . .	154
Drawing angles . . . . .	154		

## Design Abstracts . . . . . 189

## New Parts and Materials . . . . . 214

## Engineering Department Equipment . . . . . 269

## The Engineer's Library . . . . . 276

## Noteworthy Patents . . . . . 281

## Backtalk . . . . . 298

## Helpful Literature . . . . . 207

Subject Index . . . . .	17	Advertising Index . . . . .	297
Reader Service Cards . . . . .	19	Business Staff . . . . .	297

**IN THE NEXT ISSUE:** Human factors on the bridge . . . functional tolerancing . . . timers . . . catalog files . . . self-optimizing control systems . . . oscillation life of bearings . . . curved beams.

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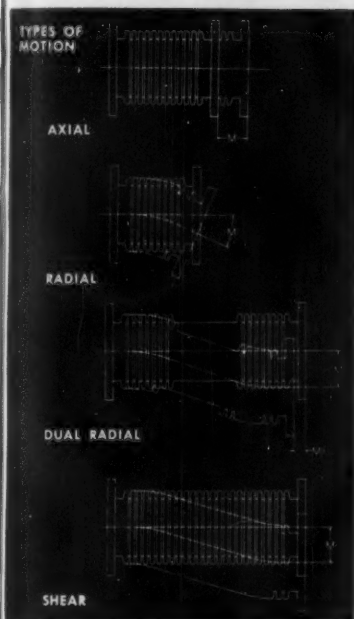
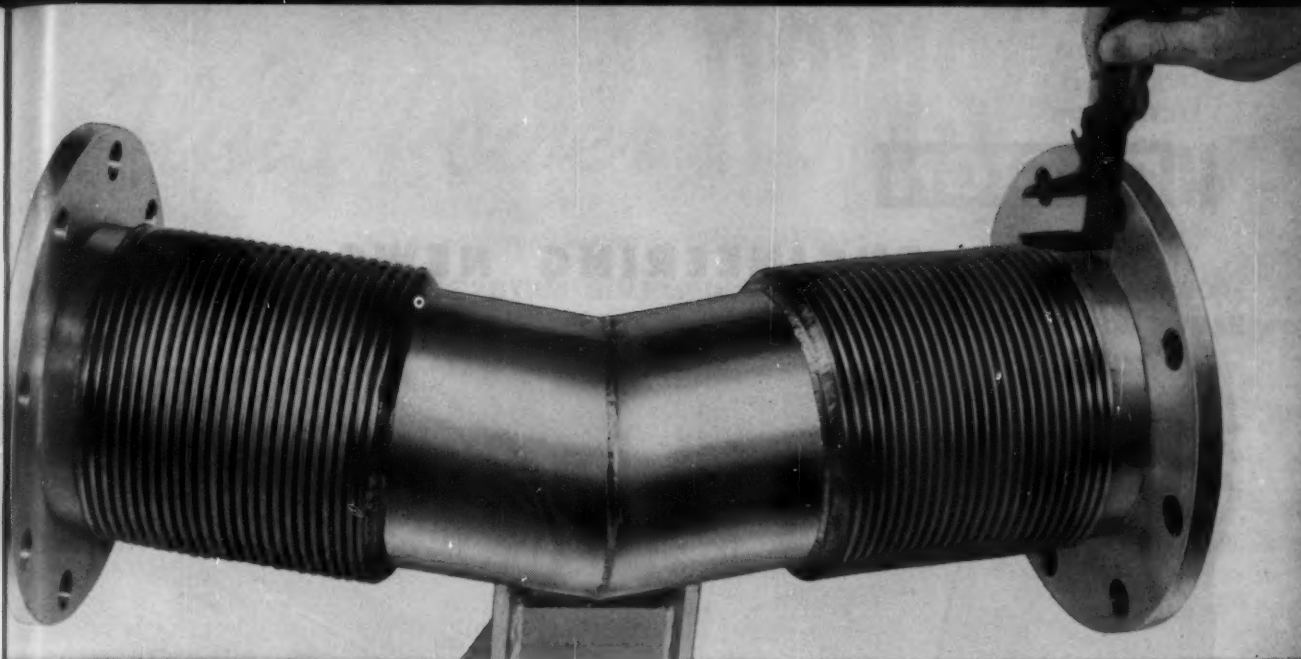


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## Expansion-joint tubing for big, tough jobs

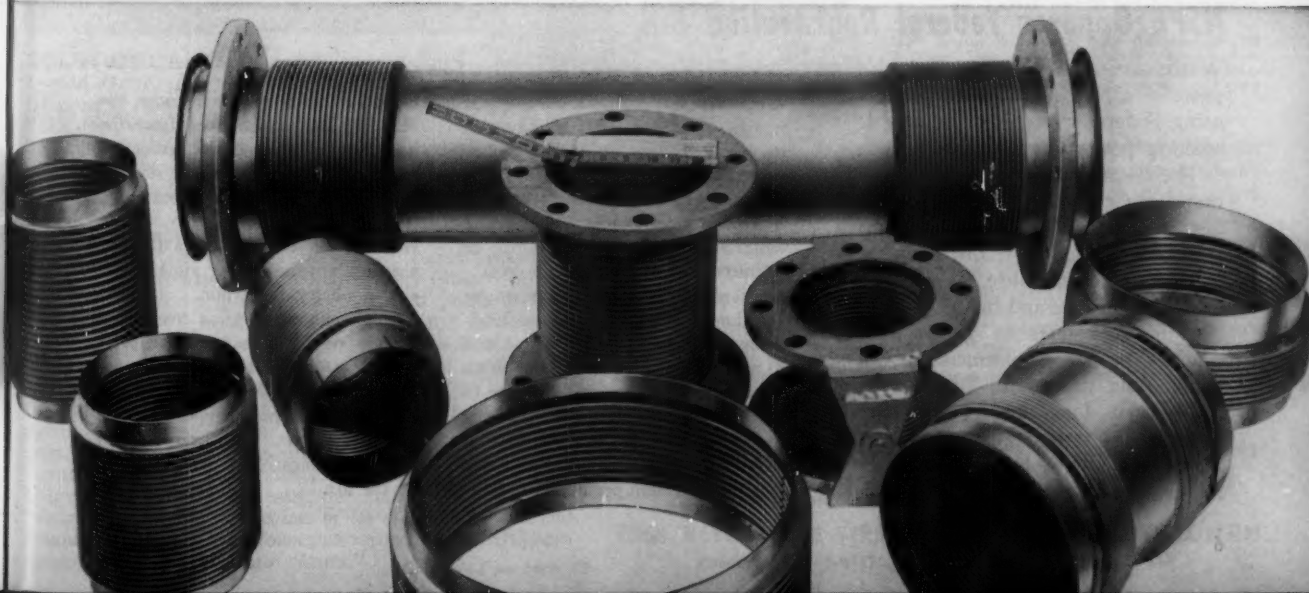
**New AX Tubing by Anaconda is available in Bronze, Stainless Steel, and other metals and alloys—from 4½" I.D. to 14" I.D.—to handle axial and lateral movement.**

Need to compensate for contraction of piping suddenly cooled to minus 300°F by a large volume of liquefied gas? Want a bulkhead seal that "gives" with hull movement? Do you need a special assembly like that above, which handles an offset and a combination of lateral and axial movement? Wherever you need large diameter tubing to take care of movement shown in drawing at left, or simple offset, write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

89128

# ANACONDA® METAL HOSE

Circle 406 on Page 19



## ENGINEERING NEWS



### Fueled for Five Years

Eight reactors will power the USS Enterprise, world's largest ship and first nuclear-powered aircraft carrier. The 1100-ft floating airbase will displace 86,000 tons, have a 252 ft wide flight deck. Its first charge of fuel is expected to last five years and permit the ship to run at sustained speeds of more than 30 knots for almost unlimited periods of time. Aluminum has been used extensively in construction of the big carrier to minimize weight. Its four plane-carrying elevators (right), each 52 ft wide and 85 ft long, are made entirely of aluminum, supported by huge 10-ft deep aluminum I-beams. Weight saving per elevator (over high-tensile steel) is 30 tons. I-beams are Alcoa 5456 aluminum plate.



### NSPE Opposes Federal Registration Bill

WASHINGTON—A bill to regulate the practice of engineering on projects using Federal government money is meeting powerful opposition.

The board of directors of the National Society of Professional Engineers recently approved a recommendation to go on record as being opposed to the measure. The registration committee and functional section for engineers in government practice, which recommended the action, told the board, "the bill in its present form would seriously weaken the state registration laws. Further, Bill H.R. 11916 would permit registration of some persons with

#### The Foley Bill

The bill's object is to further the interests of the Federal government, to encourage pursuit of the profession, and to improve performance in the profession. It covers the performance of any professional service requiring education in engineering or science on federal or public projects.

A board of registration is set up for enrollment of the new Federal Engineers, Scientists and Technicians, and to prohibit those not enrolled from engaging, or attempting to engage in professional practice, as outlined above. Registration, for two years, is renewable without examination, and late re-registration penalized.

Power of subpoena is granted the Board of Registration to enforce the law, and it shall have revocation powers. Registrations may be revoked for felony, deceit, misrepresentation, fraud or gross incompetency, or for violation of the act or aiding or abetting anyone in its violation is also cause for revocation.

Exemptions to registration are granted to any person who has filed with the Board, and is awaiting their decision, any engineer doing sales work, professional engineers who, for thirty days, and from certain states, are engaged in work covered by the act.



# Fluid Power news

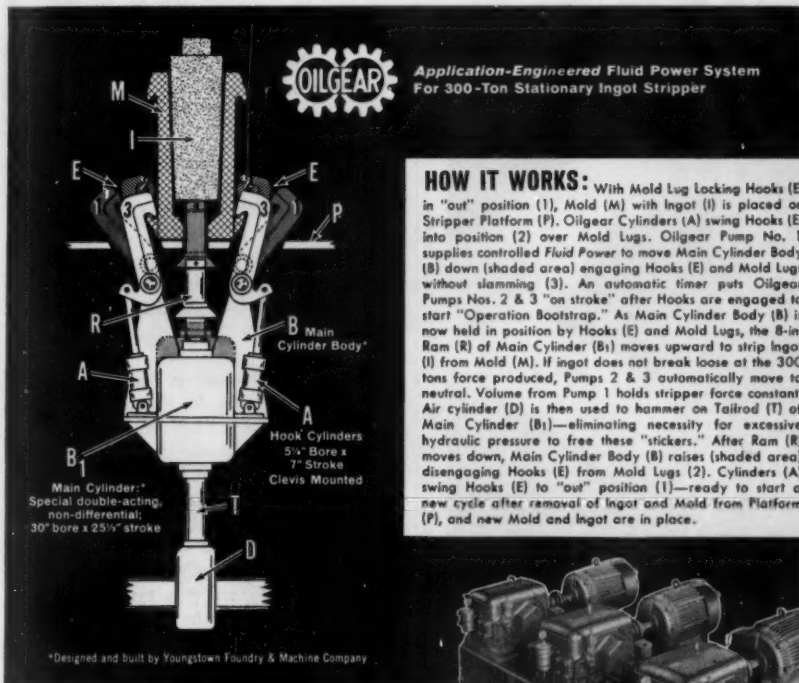
**REPORT  
NO. 11,804  
OILGEAR  
POWERED  
INGOT  
STRIPPER**

From Oilgear Application-Engineering Files

## HOW OILGEAR HEAVY-DUTY SYSTEM SIMPLIFIES POWER AND CONTROL OF 300-TON STATIONARY INGOT STRIPPER—HELPS ELIMINATE MAINTENANCE DOWNTIME

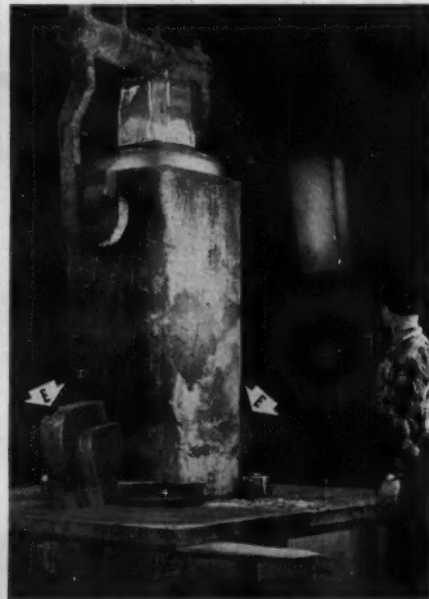
**DATA:** To replace a mechanical-type ingot stripper because of considerable maintenance downtime caused by dirt and foreign particles jamming the motor-driven ram screw—necessitating disassembly of the entire mechanism to free the threads. A hydraulically-powered, floor-mounted stripper design was approved as most convenient for the big-end-up molds used in this particular operation—would provide faster, easier maintenance accessibility at lowest over-all initial replacement cost.

**Basic Power and Control Requirements:** 1. Simplicity, and trouble-free, rugged dependability. 2. To be capable of many years of heavy-duty, rapid, 'round-the-clock operation with an absolute minimum of maintenance. 3. Must be: impervious to sand, scale, heat; compact; thrifty on electrical power input, wiring, installation downtime, floor space; completely free, if possible, from maintenance-provoking belts, chains, relays. 4. One source and responsibility for power and control systems preferred.



**SOLUTION:** An Oilgear Application-Engineered Heavy-Duty System consisting of an Oilgear "Power-Pak" incorporating 3 Type "DX-60" Variable Displacement, 2-Way, Radial Rolling Piston Pumps on a single reservoir base; a 1-in. solenoid-pilot-operated 4-Way Valve; and 2 clevis-mounted Hook Cylinders (A, above). This simple, direct-acting, locked-circuit, push-up-type stripper with remote speed and cycle control . . . space-saving, remotely located "Power-Paks" . . . automatic pressure and flood lubrication with continuously filtered power fluid . . . positive, automatic overload protection—has eliminated maintenance downtime problems encountered with the previous mechanical stripper. Long life for continuous, 'round-the-clock production is assured by this automatic, "Sealed-System"—aided by the direct application of the pneumatic jarring cylinder to free "frozen" ingots. Lower installation cost, faster—easier accessibility for preventive maintenance are but two additional advantages of this Oilgear-equipped ingot stripper. **USER STATES—**"Oilgear was selected because of its simplicity, and the trouble-free, long-life performance record of other Oilgear-equipped machines in our plants."

Circle 407 on Page 19



**ABOVE:** Oilgear-equipped Ingot Stripper "in action"—Mold Lug Locking Hooks (E) indicated. A 10,000-lb. ingot has just been "stripped" from the mold. Hooks (E) will be disengaged as soon as stripper ram is retracted.

**LEFT:** Oilgear Heavy-Duty "Power-Pak"—consisting of 3 Oilgear Type "DX-60" Variable Displacement, Two-Way Pumps on a single reservoir base used on this installation—is remotely located, isolated from heat and gritty particles present in the stripping area.

With Oilgear Heavy-Duty System Components designed for thousands of hours of continuous service at full rated load, savings are compounded with every hour of uninterrupted performance. That's why machinery and equipment manufacturers and their customers say . . .

**"for the lowest cost per year . . . it's Oilgear!"**

For solutions to YOUR linear or rotary Controlled Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements directly to . . .

## THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

Phone: Mitchell 5-6715 . . . Direct Distance Dialing Code 414

questionable qualifications, is vague in its ultimate applications, and provides an excessively generalized

definition of practice of engineering."

The House Civil Service Committee, to whom the measure has been referred, has not scheduled action.

## Varied Program Set for Sixth Mechanisms Conference

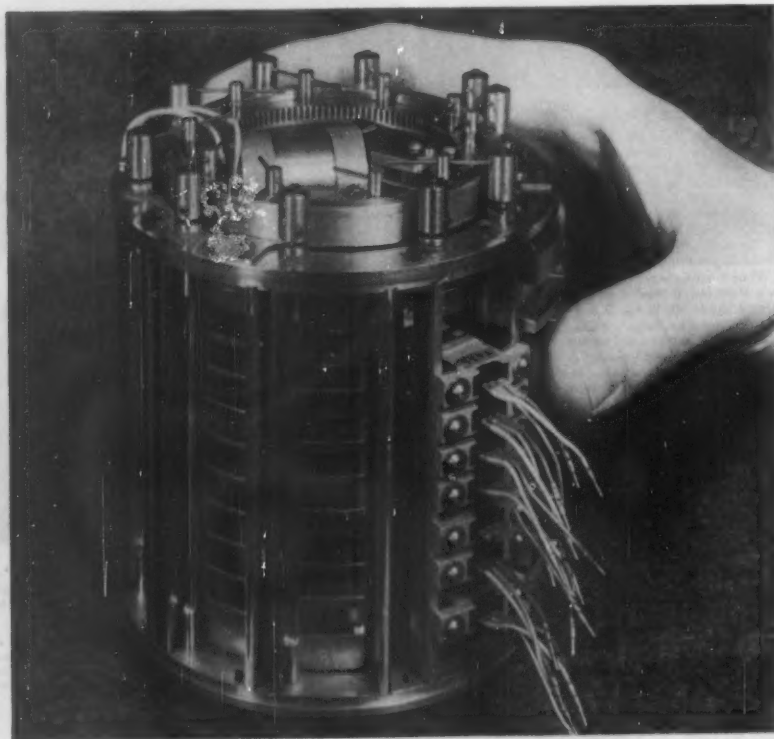
CLEVELAND—Recognized authorities in mechanisms design will present more than 15 papers during the Sixth Conference on Mechanisms at Purdue University, Oct. 10 and 11.

Co-sponsored by MACHINE DESIGN and Purdue's School of Mechanical Engineering, the Conference is probably the only one of its type in this country and provides a unique opportunity for exchange of information and ideas on mechanisms design. It is open to attendance.

Topics in this year's program include cam design, linkage design, space mechanisms, computing mechanisms, and elastokinesis.

Social highlights of the two-day meeting are a banquet on October 13 and luncheon October 14. Cost of the social affairs and a copy of the transactions are included in the \$40 registration fee.

Registration, housing, and travel details will appear in forthcoming issues of MACHINE DESIGN.



## Airborne Short Memory

One-hundred thousand bits of information can be recorded on the magnetic surface of a new miniature memory drum. Designed for use in an airborne computer, it's just 3 in. long by 3 in. in diameter. Comparable earthbound computers use a 16 by 4-in. drum. Although the airborne device is merely a thin stainless-steel shell, it can withstand stresses of more than 15 g and is not affected by high-frequency vibrations common to aircraft and missiles. Pickup and recording heads, imbedded in rectangular blocks of plastic, slide over the drum on a cushion of air. Airgap is maintained at 100-millionths of an inch, even under severe vibration conditions. Total weight of the drum assembly is 8 lb, compared to about 235 lb for a similar earth-bound memory. It was developed by IBM's Federal Systems Div. laboratories, Owego, N. Y.

## Topics

Compact comfort is enjoyed by the economy-car owner who used some of the money he saved to buy an air conditioner. The Automotive Air Conditioning Manufacturers Association says that air conditioning is desired by just as many buyers of compacts as by big-car buyers. Finding a place to install a cooling unit poses something of a problem, but hang-on units are selling briskly at \$300 and up. 1961 Falcons and Valiants will offer air conditioners as optional equipment.

Taxpayers on tape will be part of the Internal Revenue Service's system in a few years. A nationwide network of computers will check tax information on both individuals and corporations, and a central electronic brain will carry a master file of all taxpayers. Regional information transmitters are to receive returns from existing districts. IBM has the job of building these electronic tax collectors.

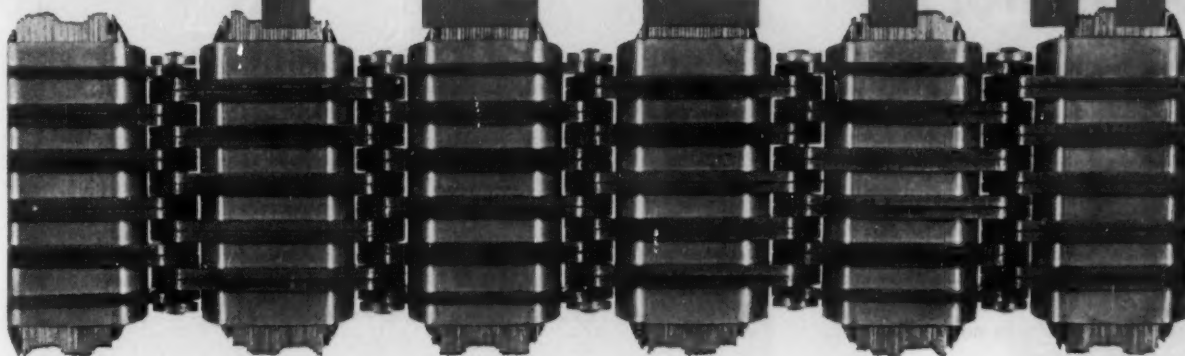
Raising the roof—and the floors, too—is a finger-tip operation at a parking garage under construction in Newark, N. J. Concrete slabs in forms 190 ft by 56 ft by 6 in. raise on pushbutton-controlled jacks at the rate of 4 ft an hour. When in place, the slabs are welded to girders. Positioning is accurate to 1/10 in.

Pushbutton purchasing, demonstrated to British retailers in a model electronic supermarket, makes the shopping cart as obsolete as the cracker barrel. In the Solartron-John Brown Automation Ltd. system, the shopper selects groceries (including specific pieces of meat) by inserting a card into pointing slots above the goods on display. The completed card goes into a processing machine at the cashier's desk, and while the customer pays his bill, automatic dispensing takes place in the warehouse. By the time the customer arrives at the delivery counter, his groceries are ready.

Astronauts will get tanked if spaceship designers follow a suggestion of Robert P. Haviland, a GE engineer. His proposal is to have furniture and instrument mountings built into an 8 by 20-ft fuel tank which would serve as crew's quarters after the fuel has been used. Equipment that would be harmed by the fuel would be sealed in bays. According to Mr. Haviland, advantage of such a dual-purpose tank is that, by reducing the payload, it would provide a practical interim means of space exploration until more powerful rocket boosters are available.

**PUT**

**TEETH**



## IN YOUR SPEED CHANGING JOBS

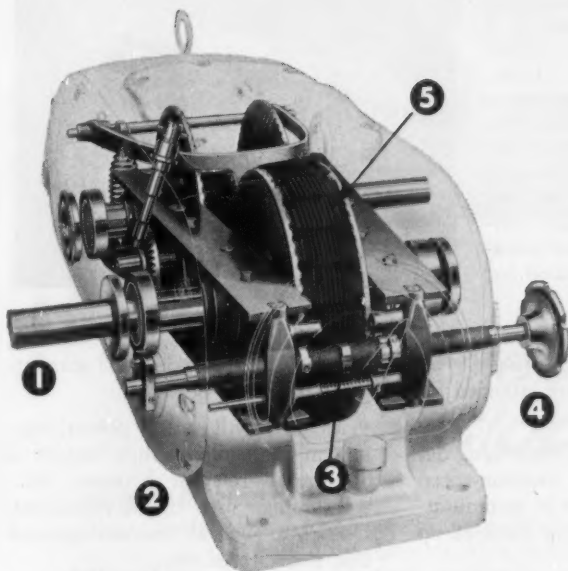
**Get the positive, accurate control that only LINK-BELT's chain-driven P.I.V. can deliver**

Yes, you put teeth into your speed changing jobs because Link-Belt P.I.V.—unlike other variable speed drives—utilizes an exclusive metal, self-tooth-forming chain.

Here's how it works! P.I.V. chain consists of a series of overlapping steel links. The links contain packs of slats which are free to move from side to side, singly or collectively, to serve as teeth. The chain meshes with radially grooved wheels, which are cut to a constant depth towards the wheel periphery. Beveled sides of the grooves offer gripping areas . . . provide a positive, nonslip contact at any speed, under all loads.

Makes changing speed simple too! A turn of the control screw simultaneously varies the effective diameters of the conically shaped wheels—closing one set, spreading the other. At the same time, the self-tooth-forming chain automatically adjusts to provide desired ratio between the input and output shafts.

**BOOK 2274**—Your Link-Belt office has Book 2274 on P.I.V. drives from ½ to 25 hp. Refer to the yellow pages of your local phone directory under Power Transmission Equipment.



(1) You can get minute speed changes and maintain them accurately while operating under full load.

(2) All-metal, totally enclosed—unaffected by atmospheric conditions. All vital operating parts splash-lubricated from a common housing reservoir.

(3) Easy-view speed indicator facilitates speed selection and adjustments to meet all requirements.

(4) An infinite number of positive, stepless speed adjustments may be made with manual, electric, pneumatic or hydraulic controls.

(5) Self-tooth-forming chain is made from a series of overlapping steel links. Links contain packs of hardened steel laminations or slats (shown above). Slats grip toothed wheels positively without slippage—give the speed you need at any setting.

1630

**LINK-BELT COMPANY:** Executive Offices, Prudential Plaza, Chicago 1. To serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarborough (Toronto 13); South Africa, Springs. Representatives Throughout the World.

**LINK-BELT**  
P.I.V. VARIABLE SPEED DRIVE



# Raysistor:

## New Component Competes Across the Board

WALTHAM, MASS.—A new circuit component developed by Raytheon Co. is claimed to outperform relays, commutators, choppers, and potentiometers at tasks that each does well. Advanced models in the design stage are also expected to compete for many jobs now assigned to vacuum triodes.

The new device, called Raysistor, is basically a four-terminal relay that's capable of very high speed and uses low power. Two terminals control the passage of information across the other two by electro-optical coupling. The control end activates a high-intensity light. When excited, the light decreases the resistance of a photoresistor (by a factor of about  $10^6$ ). The photoresistor, in turn, drives a quick-operating cell that passes both dc and ac information.

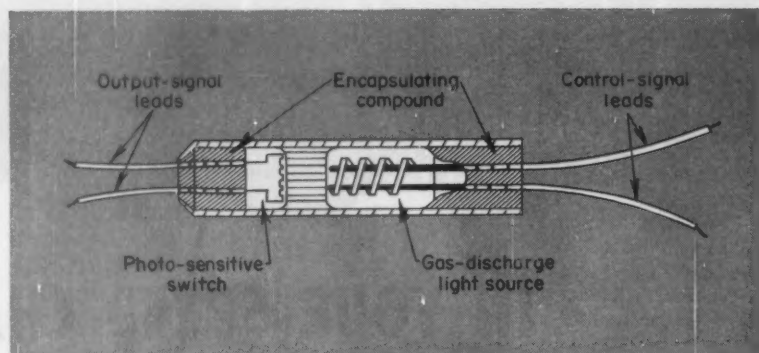
### Versatility . . .

Raysistor can be hooked up as amplifier, modulator, relay, phase shifter, or transformer, but these applications aren't the limits of its abilities. Output is not necessarily a sole function of input, and the controlled element is bilateral (characteristics don't change when current flow is reversed). In addition, the signal circuit is completely isolated from the control circuit.

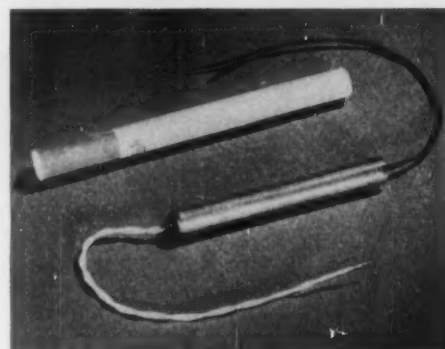
Advantages of the new component are numerous. It has no moving parts (no noise or wear), power losses are low, and it's small and light. In addition, because the drive element is a high-resistance glow tube, the device can be driven by either vacuum-tube or high-voltage transistor switching circuits.

### . . . and a range of sizes

Four models of Raysistor are planned for the near future, but only Model A is now available. Each will have a service life of about 5000 hr. Model D, the power-switching version, will be larger than the others because it will need a large light source and a photo-



Smaller than a cigarette, Raytheon's new electro-optical relay is expected to take over many circuit jobs. Used as a relay or potentiometer, for example, it's free from all contact noise; other applications range all the way up to vacuum-tube assignments. The control circuit (used to power a glow tube) is entirely independent of the signal circuit (activated when the light beam lowers photoresistor resistance).



resistor with a large junction area. The other three, measuring  $\frac{1}{4}$  in. diam by 2 in. long, are intended for instrument jobs:

- Model A is a signal-switching device designed as a medium-speed relay. Typical use is in commutating matrices with scan rates of up to 100 bins per sec.
- Model B will be a faster-acting relay designed around a new gas tube and photoresistor recently developed by Raytheon. "On" and

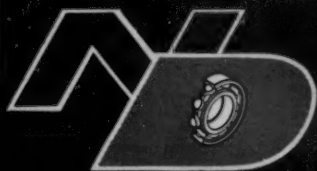
"off" constants will be in the microsecond range and it will scan up to 10,000 bins per sec.

- Model C will replace potentiometers in applications that require a continuous relation between control voltage and signal resistance. Use as a general feedback control link is also predicted.

Each of the non-power versions will control a signal ranging from dc to 5 kc with an input current of no more than 3 ma.

How Raysistor-A Stacks Up

Characteristic	Transistor	Thyratron	Relay	Raysistor-A
On-off resistance ratio	$10^4$	$10^{10}$	$10^{10}$	$10^6$
On resistance, ohms	$10^3$	negligible	negligible	$10^4$
Turn-on time, sec	$10^{-9}$	$10^{-4}$ - $10^{-7}$	$10^{-2}$ - $10^{-4}$	$3 \times 10^{-9}$
Turn-off time, sec	$10^{-9}$	$10^{-4}$ - $10^{-8}$	$10^{-2}$ - $10^{-4}$	$15 \times 10^{-9}$
Capacitance (shunt), mfd	1-20	1-2	1-10	4
On voltage drop	0-25	15	negligible	0-25
Maximum off voltage	25	200	200	200
Maximum case temperature, C	150	150	100	75
Microphony	good	fair	poor	good
Circuit noise	fair	poor	fair	good
Isolation	poor	poor	good	good
Polar	yes	yes	no	no



## CASE HISTORIES



Frequency Time Standard instruments, selected by Smithsonian Institution to clock satellites, are equipped with New Departure ultra-precise ball bearings.



Photos: Courtesy Ernst Norman Laboratories and Bodine Electric Co.

## *Ultra Precise Ball Bearings Help "Clock" A Satellite!*

### CUSTOMER PROBLEM:

Require ultra-precise bearing design for Bodine electric motor used in satellite-tracking micro-clock. Bearings must provide uniformly low starting torque, precise location of rotor shaft and minimum maintenance, to help mechanism achieve time determinations to 0.001 second.

### SOLUTION:

N/D Sales Engineers studied special bearing requirements, and recommended New Departure ultra-precise ball bearings. These ball bearings measured up to every requirement for micro-clock motors . . . thanks to New Departure's advanced equipment for research, devel-

opment and production. N/D equipped micro-clocks, selected by the Smithsonian Institution, are operating in a dozen locations around the world, keeping track of vital satellite movements . . . to one milli-second and better!

If you're manufacturing or designing electric motors for any high precision applications, including instruments, why not call on New Departure? N/D engineering and research facilities are turning out the latest in high precision instrument ball bearings and advanced ball bearing designs. For more information write Department LS, New Departure Division, General Motors Corporation, Bristol, Conn.



**NEW DEPARTURE**  
**BALL BEARINGS**  
*proved reliability you can build around*

## Nuclear Flight—or Fancy?

Several configurations of nuclear plane are under consideration, and at least two distinct engine types. Sketches released recently by Convair Div., General Dynamics Corp. and the Air Force show aircraft that could fly to the limit of crew endurance. The planes lack conventional tails, having vertical stabilizers on their swept wing tips. The model shown would be powered by an indirect-cycle nuclear engine. Liquid-to-air heat exchangers would transfer reactor heat to engines.



## Polyethylene Ammunition for Shotguns and Revolvers

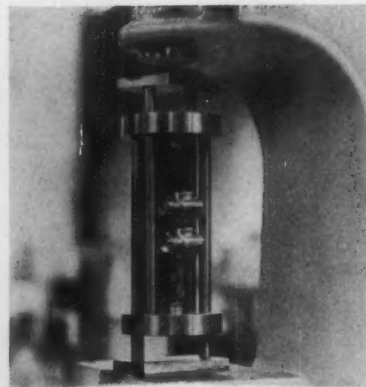
PLASTIC SHELLS for 12-gage shotguns and cartridges for .38 and .45-caliber revolvers are now on the market. Development had to await toughened linear polyethylene.

The shotgun shells, complete with steel heads, are designed for rugged duty. Developed by Peters Cartridge Div., Remington Arms Co., they perform well under the worst conditions: They don't swell in rain, snow, or sleet, nor do they scuff or mar. Their weatherproof qualities also result in loads that stay fresh longer, and the plastic (transparent) case enables hunters to visually inspect the shot before firing the shell.

The revolver cartridges, developed by Dow Chemical Co., are designed for training purposes (a revolver's muzzle velocity is much higher than that of a shotgun). Loaded with wax bullets and powered with a primer only, the cartridges are intended for use by police departments to teach rookies to shoot. Professional lawmen who have tested the ammunition say it's accurate up to about 20 ft.



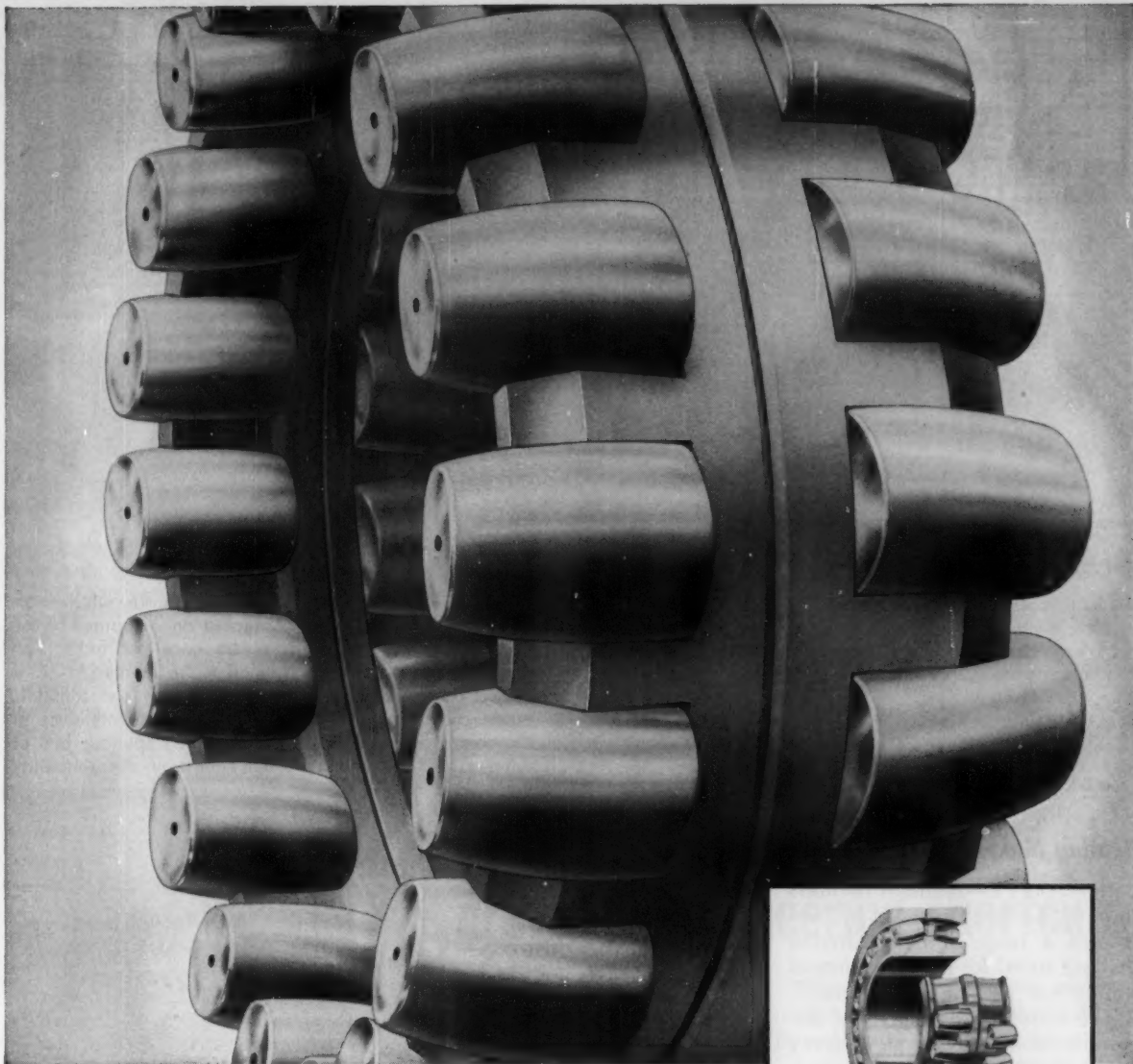
Extensive testing was completed before Remington placed the new plastic shotgun shells on the market. Intended as an ultrareliable ammunition for hunters, the shells were water soaked and shaken in hunting-coat pockets for hours, (above), compressed (right, above), and exposed to a complete cycle in a home-washing machine (right). The plastic shells were not damaged by this kind of mistreatment, and in all cases they outperformed other types of shotgun ammunition. Shells are development of Remington's Peters Cartridge Div.



Plastic revolver cartridges, developed by Dow for Colt's Patent Fire Arms Mfg. Co., are intended primarily for target practice. The ammunition, consisting of a plastic cartridge loaded with a wax bullet and powered with a primer only, produces no recoil and is accurate up to about 20 ft. Heaviest use will come from police departments, but it will also enable women and youngsters to learn to handle firearms safely.



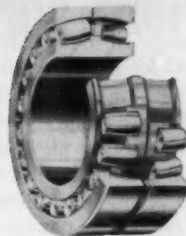




## "Caged" for Longer Life!

The two land-riding cages in Torrington Spherical Roller Bearings assure proper roller spacing and guidance, even under rugged conditions of shock load and sustained high speeds. These fully machined cast bronze cages operate independently. Their design eliminates drag on rollers. These high-strength cages help bearings give longer life by providing low friction, smooth running and cool operation. Highly effective and generous lubrication of all contact surfaces is achieved with the open-end cage design.

The result: Torrington Spherical Roller Bearings are built to give extra years of unmatched service life in heavy-duty applications. Torrington's long experience in design, engineering and manufacture of every basic type of anti-friction bearing provides the finest spherical roller bearings available. You'll find it pays to standardize on Torrington.



### Superior design features of TORRINGTON SPHERICAL ROLLER BEARINGS

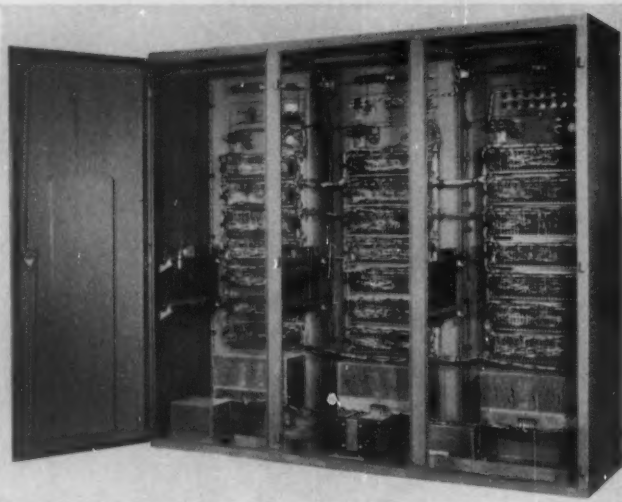
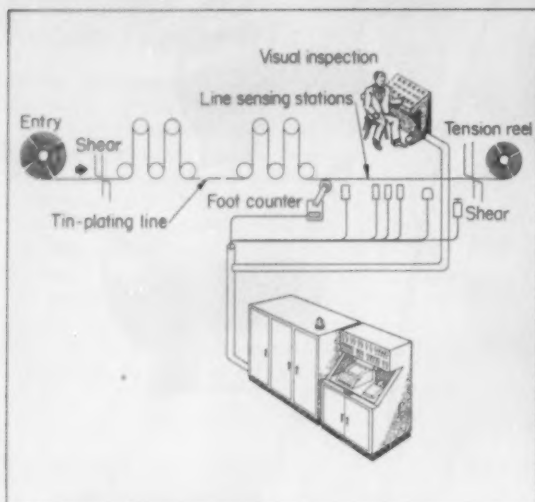
- integral guide flange for roller stability
- asymmetrical rollers seek flange for positive guidance
- electronically matched rollers
- size-stabilized races
- fully machined land-riding bronze cages
- controlled internal clearances
- even load distribution
- inherent self-alignment
- long service life

*progress through precision*

**THE TORRINGTON COMPANY**

**TORRINGTON BEARINGS**

South Bend 21, Indiana • Torrington, Conn.



## Democratic Computers Vote on Tin-Plate Quality

Majority opinion of a panel of computers passes or rejects tinplate coils in a new quality-control system. Developed by Airborne Instruments Laboratory, division of Cutler-Hammer Inc., the data-accumulation equipment includes three computers that monitor one production line, interpret the same information, and come up with individual answers. A vote accumulator collects the electronic ballots, then records both the majority finding and which way each computer voted. As shown in the diagram (left), the computers are

connected in parallel. Signals from each sensor, which spots defects in the tin plate, are correlated on a footage-of-coil basis by a tachometer which pulses once per foot. Advantages of the system are claimed to be numerous: 1. If even two computers break down, production can continue. 2. Work schedules don't have to allow for maintenance of quality-control equipment. 3. Accumulated spurious bits of information in one computer don't destroy the reliability of the printed record.

## Beating Makes Better Packing

LANCASTER, PA.—Addition of fibers to pure fluorocarbon resins has uncovered a range of new materials that are suited for a wide variety of sealing and packing applications.

The nonadhesive property of fluorocarbons—an advantage in many mechanical applications—has long precluded the addition of filler materials. A beater saturation process, patented by Armstrong Cork Co., now permits the resin to be thoroughly distributed through an asbestos or other inorganic filler. The resulting material, produced in sheet form, is called Fluorocarbon Accopac.

Completely unaffected by the common fuels and solvents, it is also inert to most chemicals. Stable from  $-425^{\circ}\text{F}$  to  $500^{\circ}\text{F}$ , the packing has a creep resistance said to be unequalled by any other fluorocarbon; deformation under load is also excellent.

The manufacturers suggest application of their materials in the paint, chemical, and petroleum industries as gaskets for glass and lead-lined equipment, and in the aircraft and missile industries for systems using cryogenic materials or fuels.

## Metals Matters

### Cooling molten metals . . .

at the rate of 2,000,000 degrees per second produces new alloys of hard-to-combine metals—copper-silver, germanium-silver, and gallium antimonide-germanium. In these alloys, ultramicroscopic grains of the component metals mix; normally the metals segregate in different grains. "Splat cooling," developed at California Institute of Technology, accomplishes the mixing: The molten metals are splatted against the rim of a wheel which revolves rapidly and is kept at  $-300^{\circ}\text{F}$ . Thin pieces of foil are expected to have unusual electrical and magnetic properties.

### Welding coated steel . . .

is done by the magnetic force projection method on stock as thin as 0.015 in. without damaging the coating. In magnetic-force welding, the same current surge which brings the parts to welding heat is used to energize a magnet. The magnet drives a forging hammer down on the weld projection, upsetting it at the instant of maximum heat to forge the weld. Welder was built by Precision Welder and Flexopress Corp., Cincinnati.

### Zirconium alloys for reactors . . .

will have to be of higher quality and less expensive than those now available, General Electric's Atomic Power Equipment Dept. told leading zirconium suppliers. GE listed the following characteristics an alloy should have for use in boiling-water reactors: Corrosion resistance equal to zirconium-2; strength equal to zirconium-2, with greater ductility; no appreciable deterioration under irradiation; low hydrogen pickup; and resistance to rapid failure with defects.

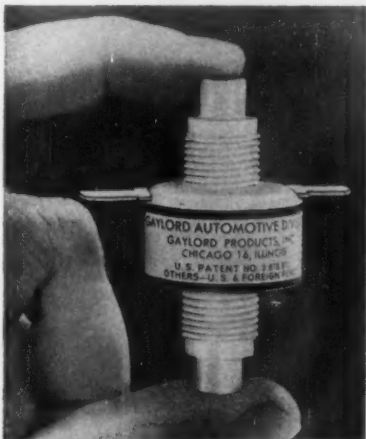
### Galvanized-steel auto bodies . . .

are gaining favor, but need an economical process for production-line resistance spot welding. The American Zinc Institute is trying to develop such a process at the Budd Co., Philadelphia; it's investigating electrodes, welding techniques, and characteristics of galvanized sheets. Goal of AZI research is to develop techniques and associated accessories for welding at the same rate and on a similar maintenance basis to that presently used by auto makers in welding uncoated steel strip.

## Compact Controller



**Quick and compact**, a new numerical control offers major production savings. First models of the Mark Century, by General Electric, will be of the numerical-contouring type. The control will translate arcs directly into machine motion, eliminating costly point-to-point programing. A typical contouring job for previous controls would have required a medium-size computer to interpolate curves into thousands of positioning co-ordinates. Later models will have options for standard co-ordinate positioning, or positioning-plus-contouring.



## Motion Detector

**Virtually frictionless in operation**, a motion detector promises to have many industrial applications. It was originally developed by Gaylord Automotive Div., Gaylord Products Inc., Chicago, to prevent automobiles from "creeping" while idling in gear. The mechanism is mounted on the speedometer drive. It actuates a solenoid—once the brakes have been applied—which holds them on to a predetermined pressure. Pressing the accelerator operates a second switch to release the solenoid. Other uses now suggested are for preventing buses from moving with their doors open, or for triggering a warning when conveyor-line materials start to back up.

# DRAFTING TRENDS



## Helpful new booklet suggests drafting, engineering shortcuts

Just published—"DRAFTING SHORTCUTS" is a completely new booklet of helpful ideas and aids for engineers, draftsmen and students. It is well illustrated, clearly and logically written. It contains a wealth of time-saving tips to speed both routine and specialized tasks.

The ideas selected were submitted by professionals and judged by an impartial panel of widely recognized authorities on the various topics covered.

As an example, the section covering *Calculating Ideas* includes a simple means of locating stress points on cantilevered beams, also a simple method for retaining fundamental trigonometric relations.

In the section on *Drafting Shortcuts*, our editors have come up with topics like a simplified, fast and easy method for drawing gear teeth profiles and a rapid means of showing twisted wire elements.

The *Engineering Data* section covers new, easy-to-use shortcuts to formulas and engineering data.

There's a special section devoted to time-saving techniques on the drawing board, too. One of the suggestions on how to make life easier for the draftsman tells how to use a bent paper clip as a variable guide for making section lines.



For your free copy of "Drafting Shortcuts" contact your POST dealer or write today to the Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.



SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES  
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE





## RIVNUTS® streamline tank design; eliminate damage to product

This oil reservoir, fabricated by Stolper Steel Corporation, Menomonee Falls, Wisconsin, for a husky new Allis-Chalmers tractor-shovel, requires removable cover plates. This is accomplished with flush-mounted RIVNUTS and threaded bolts.

With RIVNUTS, all possible damage is eliminated, since the RIVNUTS project inside the tank. Installation is simple: holes drilled and countersunk, RIVNUTS upset with a heading tool. Flush installation permits obtaining a liquid-tight joint without grinding.

RIVNUTS are the only one-piece blind rivets with internal threads. If you'd like recommendations on a specific fastening problem, please send a print of your part. For descriptive bulletin, see Sweet's Product Design File, or write *Dept. MD-8, B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Akron, Ohio.*



# B.F. Goodrich Rivnuts



# Reader Information Service

## SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle item Number on a Yellow Card—following page.

Adhesives, Edit. 263; Adv. 42, 239  
Aluminum and alloys, Adv. 125, 255

Bearings,  
ball, Adv. 11, 64, 73, 290  
miniature, Adv. 198, 249  
roller, Adv. 13, 72, 94, 95, 213, 300  
sleeve, Adv. inside front cover, 72, 84, 119  
wire-race, Edit. 30

Bellows, Adv. 49  
Black-box flight, Edit. 26  
Blowers, Adv. 35, 220  
Books, Edit. 276  
Brakes, Edit. 216; Adv. 291  
Brass (see Copper and alloys)  
Bronze (see Copper and alloys)  
Brush holders, Adv. 294

Cams, Edit. 146  
Capacitors, Edit. 22, 214

Castings,  
die, Adv. 276, 290, 295  
investment, Adv. 194  
iron, Adv. 257  
malleable iron, Adv. 104, 105, 271  
meehanite, Adv. 51, 267

Chain,  
conveyor, Adv. 209  
transmission, Adv. 75, 211, 215, 227, 229, 292

Circuit breakers, Edit. 258; Adv. 91

Clamps, Edit. 233, 253

Clutches, Edit. 214; Adv. 115, 130, 131, 196, 218, 295

Coatings,  
decorative, Adv. 67  
protective, Edit. 268; Adv. 43, 54, 55, 67, 219, 234, 235

Coding system, Edit. 168

Compressors, Edit. 172; Adv. 286

Computers, Edit. 41, 198, 207

Connectors, electric, Edit. 200

Contacts, Edit. 151; Adv. 45

Containers, Adv. 281  
Controlling pressure, Edit. 155

Control systems,  
electric, Edit. 170  
hydraulic, Adv. 7  
pneumatic, Edit. 285

Controls,  
hydraulic, Edit. 263  
pneumatic, Adv. 295

Copper and alloys, Edit. 231; Adv. 119

Counters, Edit. 239; Adv. 208

Couplings,  
shaft, Adv. 48, 114, 187, 204, 293, 296

Critical speeds, Edit. 152

Cylinders,  
hydraulic, Edit. 220; Adv. 50, 80, 117, 268  
pneumatic, Adv. 50, 56, 117

Designing with vinyls, Edit. 175

Drafting equipment, Edit. 269; Adv. 15, 103, 118, 188, 194, 197

Drafting techniques, Edit. 154

Drives, adjustable speed, Edit. 237; Adv. 9, 52, 53, 111, 130, 131, 243, 256, 260, inside back cover

Electric equipment (see specific type)

Electronic equipment, Adv. 244

Energy conversion processes, Edit. 189

Engineering department (see Management or Drafting)

Engineering office, planning, Edit. 138

Engineers, Edit. 22

Engines, Edit. 202; Adv. 219

Fans, Adv. 110

Fasteners,  
bolts, studs, screws, Edit. 214; Adv. 61, 129, 233, 250, 266  
insert, Adv. 16, 272  
nuts, Edit. 207; Adv. 58, 136  
quick operating, Adv. 87  
retaining rings, Adv. 96, 196  
rivet, Adv. 16, 237

Felt, Adv. 278

Fiber, Adv. 238, 239

Finishes (see Coatings)

Fittings, pipe, tube, and hose, Edit. 254; Adv. 210, 224, 232, 245

Forgings, Adv. 100, 212, 231

Function generator, Edit. 148

Gages (see also Instruments)  
pressure, Adv. 283

Gaskets, Adv. 2, 92, 291

Gears, Edit. 201; Adv. 123, 293

Governors, Edit. 281

Handles, Adv. 288

Heading, Edit. 185

Heaters, Adv. 220

Honeycomb materials, Adv. 68

Hose, metallic, Edit. 149, 253; Adv. 5, 78, 210, 224

Hydraulic equipment (see specific type)

Increases, speed, Adv. 200

Instruments, Edit. 22, 44, 242; Adv. 31, 297

Insulation, Edit. 228, 251

Jacks, worm gear, Adv. 296

Lubricants, Edit. 222, 260

Meetings, Edit. 45

Metals (see specific type)

Metalworking equipment, Edit. 167; Adv. 33, 128, 275

Meters, Edit. 261; Adv. 289

Missiles, Edit. 25

Motors (electric),  
fractional and integral hp, Edit. 227, 257; Adv. 46, 47, 57, 62, 63, 199, 222, 252, 254, 265  
gearmotors, Adv. 216, 259  
subfractional hp, Adv. 289

Motors,  
pneumatic, Adv. 134  
torque, Adv. 66

Mountings, vibration and shock, Edit. 254; Adv. 226, 247

Nickel and alloys, Adv. 93

## SUBJECT INDEX (continued)

- Packings, Adv. 44, 223, 251  
 Perforated metals, Adv. 269  
 Pillow blocks, Adv. 73, 290  
 Plastics, Edit. 242, 244, 257; Adv. 59, 60, 228, 277, 282  
     laminates, Edit. 224, 239; Adv. 70, 217  
 Plugs, Adv. 279  
 Pneumatic equipment (see specific type)  
 Potentiometers, Edit. 218  
 Powder metallurgy, Adv. 76, 77  
 Predicting reliability, Edit. 178  
 Pumps,  
     hydraulic, Edit. 198, 266, 283; Adv. 71, 191, 202, 225, 264  
     pneumatic, Adv. 205  
 Pushbuttons, Adv. 40, 41  
  
 Recorders, Edit. 150, 274  
 Reducers, speed, Adv. 88, 89, 98, 99, 106, 107, 114, 115, 200, 261  
 Regulators,  
     flow, Edit. 240  
     pressure, Adv. 258  
 Relays, Edit. 214; Adv. 126, 193, 216  
 Resistors, Edit. 222, 281; Adv. 126  
 Rotary joints, Edit. 284; Adv. 90, 132, 133  
 Rubber, Adv. 102, 108, 109, 113, 187, 274  
  
 Seals, Edit. 214, 254, 282; Adv. 2, 102, 122, 223, 242, 285, 288, back cover  
     mechanical, Edit. 236  
 Shafts, flexible, Adv. 69, 124  
 Shakers, Adv. 206, 207  
 Shapes, special, Edit. 220  
 Sheaves (see Pulleys)  
 Silicones, Adv. 37, 38  
 Slip rings, Adv. 236  
 Spring stocks, Adv. 230  
 Springs, Adv. 65, 66, 67, 112, 203, 244, 291  
 Sprockets, Adv. 294  
 Starters, motor, Adv. 120, 121, 127  
 Steel, Edit. 204; Adv. 21, 83, 241, 248  
     stainless, Adv. 29  
 Switches, Edit. 224, 227, 233, 260, 264;  
     Adv. 116, 127, 195, 276  
  
 Thermal stresses in design, Edit. 160  
 Thermostats, Adv. 48, 79, 85, 86  
 Timers, Edit. 147, 244; Adv. 208, 263, 270  
 Titanium, Adv. 82  
 Transmissions, adjustable speed, Adv. 81  
 Tubing, Edit. 231, 264; Adv. 97, 236, 240, 258, 273  
  
 Universal joints, Edit. 216; Adv. 253  
  
 Valves,  
     hydraulic, Edit. 248, 260, 261, 266; Adv. 49, 135, 221, 284  
     pneumatic, Edit. 170, 266; Adv. 1, 74, 201, 221, 288, 289  
  
 Washers, Adv. 220  
 Wire and wire products, Edit. 218; Adv. 287  
 Wood, Adv. 246

## USE A YELLOW CARD for More Information...

**CIRCLE ITEM NUMBERS**—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

**EDITORIAL CLIPSHEETS**—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

## Index to New Parts & Helpful Literature BY ITEM NUMBERS

### HELPFUL LITERATURE—descriptions start on page 207

	ITEM NUMBER		ITEM NUMBER
Computer Terminology .....	671	Secondary Batteries .....	695
Miniature Lock Nuts .....	672	Lip Seal .....	696
DC Capacitors .....	673	Trimmer Potentiometers .....	697
Thermocouple Assemblies .....	674	Miniature Connectors .....	698
Glass Tubing .....	675	Fan Motors .....	699
Electric Impulse Counters .....	676	Tubing Selection .....	700
Stainless, Nonferrous Castings .....	677	Alloy Fasteners .....	701
Slip Clutches and Brakes .....	678	Fluids and Lubricants .....	702
Pumping Problems .....	679	Cable and Wire .....	703
Fittings and Hose .....	680	Mountings, Mounting Systems .....	704
Solid-State Circuits .....	681	Self-Locking Nuts .....	705
Steel Plate and Sheet .....	682	Throttle Valves .....	706
Liquid-Level Gages, Valves .....	683	Adjustable-Speed Drives .....	707
Leveling Screws .....	684	Kennametal and Kentalium .....	708
Extrusions, Die Forgings .....	685	Directional Valves .....	709
Roller Chain .....	686	Temperature Regulators .....	710
Nylon Pressure Tubing .....	687	Teflon TFE and 100 FEP .....	711
Electrical Connectors .....	688	Shaped Wire .....	712
Tenite Polypropylene .....	689	Plug and Receptacle Connectors .....	713
Load-Bearing Nut .....	690	Sound Control .....	714
Flow-Rate Alarms .....	691	Nylon Bobbins and Washers .....	715
Environmental Chambers .....	692	Rotating-Shaft Seals .....	716
Control Valves .....	693	Stainless-Steel Tubing .....	717
Steel Couplings .....	694		

### NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 214

	ITEM NUMBER		ITEM NUMBER
Cap Screw .....	718	Oriented Teflon .....	751
Tantalum Capacitors .....	719	Elapsed-Time Indicator .....	752
V-Type Seals .....	720	Digital Display .....	753
Adjustable Slip Clutches .....	721	Welding Fittings .....	754
Microminiature Relays .....	722	Explosive Valves .....	755
Universal Joints .....	723	Inertial Dampers .....	756
Internal Expanding Brakes .....	724	Insulating Material .....	757
Wire and Cable Strapping .....	725	Quick-Operating Clamps .....	758
Potentiometer and Dial .....	726	Steel-Armored Hose .....	759
Complex Metal Shapes .....	727	Ceramic-Metal Seal .....	760
Hydraulic Cylinders .....	728	Mounting System .....	761
Solid-Film Lubricant .....	729	Coated Dacron .....	762
Variable Resistor .....	730	Electric Motors .....	763
Rotary Limit Switch .....	731	Surface Treatment .....	764
Expoxy-Glass Laminates .....	732	Motor Protector .....	765
Cast-Iron Footswitch .....	733	Plastic Valves .....	766
Machine-Tool Motors .....	734	Dry Lubricant .....	767
Wire Insulation .....	735	Snap-Action Switch .....	768
Gang Channel .....	736	Control Valve .....	769
Zippered Tubing .....	737	Maximum-Reading Meter .....	770
Copper Alloy .....	738	Pressure Controls .....	771
Switch-Light .....	739	Synthetic-Rubber-Base Adhesive .....	772
Cable Clamps .....	740	Stepping Switch .....	773
Mechanical Seal .....	741	Spaghetti Tubing .....	774
Glass-Fiber Cloth .....	742	Canned Pump .....	775
Adjustable-Speed Drive .....	743	Two-Way Solenoid Valve .....	776
Compression Tape .....	744	Vinyl-Clad Metal .....	777
Electronic Counter .....	745	Illuminated Magnifier .....	778
Metal-Composite Laminates .....	746	Drafting Machine .....	779
Induction Motor .....	747	Direct-Writing Oscillograph .....	780
Flow Regulator .....	748	Technical Stamps .....	781
Epoxy Casting System .....	749	Vacuum Oven .....	782
Ammeters, Voltmeters .....	750	Portable Tape Recorder .....	783

# **MACHINE DESIGN** **Aug. 18, 1960**

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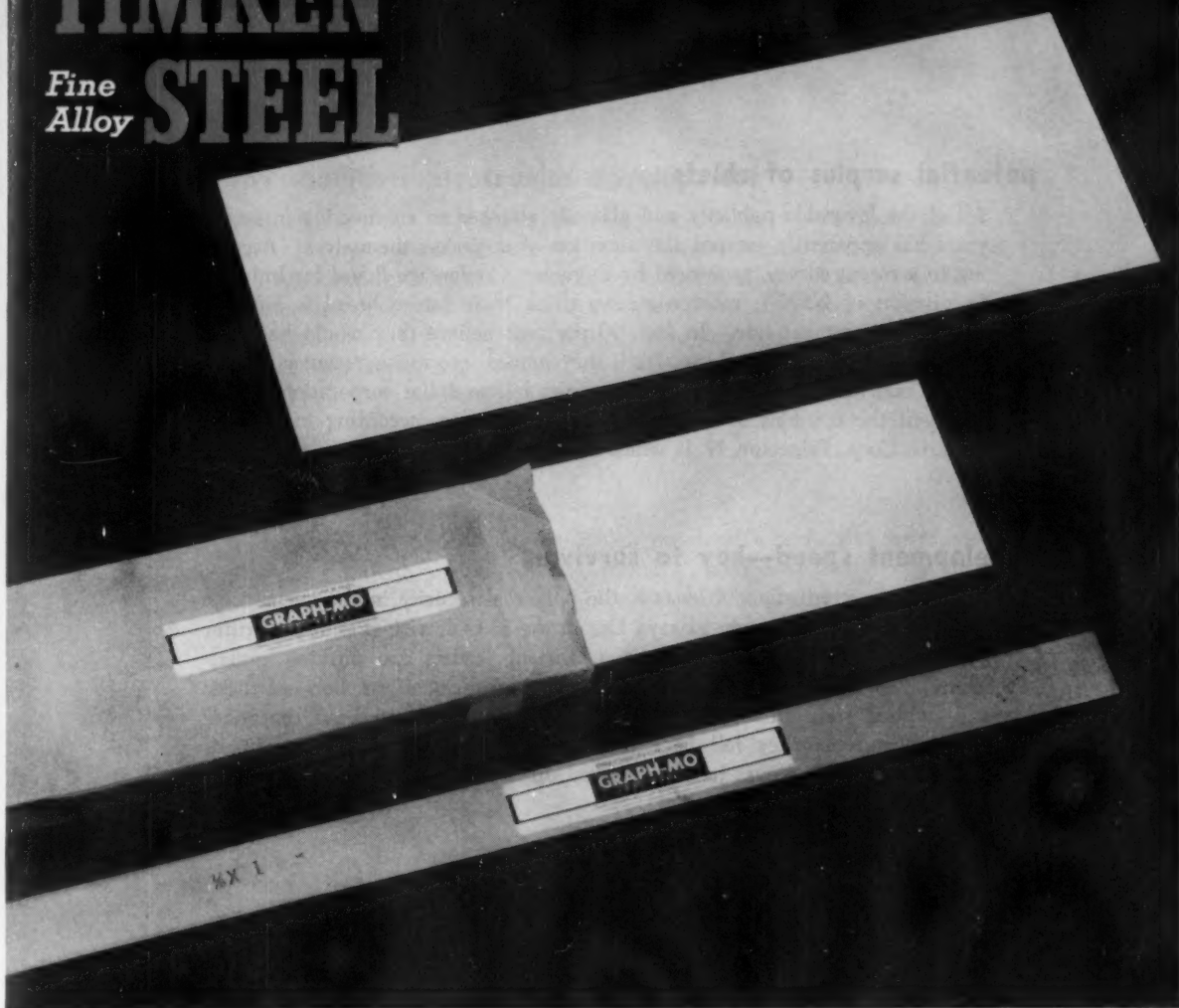
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### **potential surplus of chiefs**

All of the favorable publicity and glamour attached to engineering in recent years has apparently escaped the attention of engineers themselves. According to a recent survey, sponsored by Engineers Conference Board for Industry (a division of NSPE), most engineers think their future bread is buttered on the management side. In fact, 90 per cent believe they would be better off in terms of money and prestige if they moved into management positions. Survey conclusions, based on data from ten billion-dollar corporations, fairly represent the opinions of engineers across the nation, according to Opinion Research Corp., Princeton, N. J., which conducted the survey.

### **development speed—key to survival**

Speed in the cultivation of ideas is the only real security in the current age of fast-expanding technology, says Dr. Bruce S. Old, vice president, Arthur D. Little Inc. Companies that are consistent leaders are pushing experimental programs at maximum rate, balancing their efforts between basic and applied research and development. Competition is so keen that once the leaders relax they fall back into the pack. If a corporation responds slowly to new findings, it often wakes up too late and finds itself very mediocre, if not out of business.

### **for rent: precision**

Small companies and colleges can now afford the world's fine scientific instruments. Several instrument makers, including RCA and Perkin-Elmer Corp., now offer leasing plans that are designed to make available electron microscopes and other expensive equipment to small laboratories. The RCA plan calls for no down payment and a five-year lease. Rent applies to the purchase price. The Perkin-Elmer plan is similar, except that the lease runs for three years.

### **the cost of defense (capacitor category)**

Missile misfires on any occasion are expensive; in time of war, the cost of one fizzle might well be incalculable. To insure the dependability of its forthcoming arsenal of Minuteman ICBMs, the Air Force has pulled all stops on the subject of reliability. A typical example: General Electric has just been awarded a \$2.4-million contract to cure the effects of old age in capacitors. The goal: Development of solid electrolytic Tantalytic capacitors with a minimum failure rate of 0.001 per cent per 1000 hours (not more than one unit out of 100,000 will fail per 1000 hours of operation). According to GE, "the program should generate a wealth of information for capacitor users."



## **Europe shortcuts electronics development**

Within five years, the European electronics industry will pull even with the U. S. in engineering methods, says Herman Schaevitz, president, Schaevitz Engineering. Instrumentation men in England and France are skipping intermediate stages in electronic development. Although they've been highly dependent upon U. S. testing and production devices for a long time, they've learned well from our equipment, says Schaevitz, and differences between our designs and theirs are narrowing rapidly.

## **which way up?**

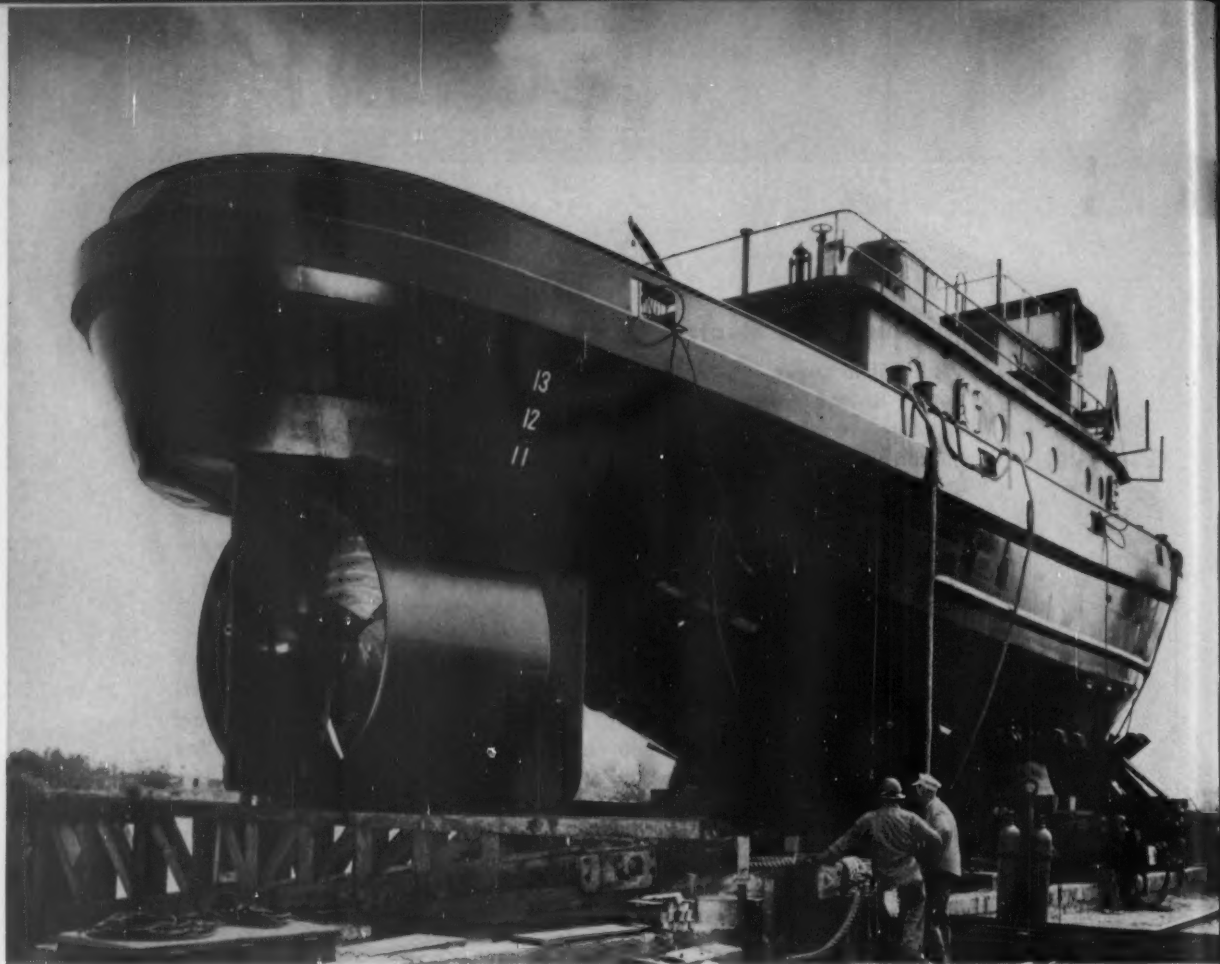
After years of engineering effort, which produced a wide and weird assortment of prototype VTOL aircraft, military chiefs are finally consolidating their programs. Immediate single objective will be design and construction of a large VTOL transport which can be used by all of the services to further evaluate and define their field requirements for this type of aircraft. Most VTOL concepts which have been flight tested will be considered for the multi-service craft, including tilt-wing and deflected-slipstream types. The unloaded-rotor system (fixed wings take over in forward flight) apparently has the greatest support, however.

## **new radiation mischief**

Researchers who recently uncovered a new radiation hazard are now searching for ways to counteract it. When transient radiation (gamma rays and neutrons) strikes electronic instruments, they act up, components don't function properly, and false data are sent out or received. Dose rates don't have to be high, and even "safe" radiation levels are unsafe for electronics, says the Defense Dept. Implications are serious because computers, missiles, and defense electronics systems are all susceptible.

## **voila la difference**

Women at work present special problems, many stemming simply from employers' overlooking their specific characteristics and treating them the same as men. Feeling against females is such that, according to a recent study of male executives, 81 per cent wouldn't hire women engineers and most of the remainder was "dead set" against letting the girls advance to middle management. A report in *Industrial Relations News* suggests that, while a man can be ordered, a woman must be persuaded. This situation results from a high sensitivity to criticism (because they are conditioned to expect praise) and a lack of emphasis on responsibility and job loyalty during their training. A successful supervisor of women will: 1. Recognize in what respect they differ from men. 2. Treat them accordingly. 3. Not let them know it.



Unprecedented power and maneuverability are built into a deep-water tug fitted with a Kort nozzle. Surrounding the *Dravo Pioneer's* 9-ft propeller, the airfoil-shaped nozzle increases thrust. A main rudder and two astern rudders, all mounted in the nozzle jet, utilize the high power for rapid, exact maneuvering. Supplementing a conventional wheel, steering levers produce quick movements and control backing rudders.

Part of the largest nonmilitary order ever placed for Jeeps, this Willys Fleetvan is one of 3210 to be built for mail delivery. Right-hand drive and an automatic transmission make work easier for the mailman. Safety feature is "vista-vision," which lets the driver see the road 3 ft in front of the bumper. Cargo space is 110 cu ft.



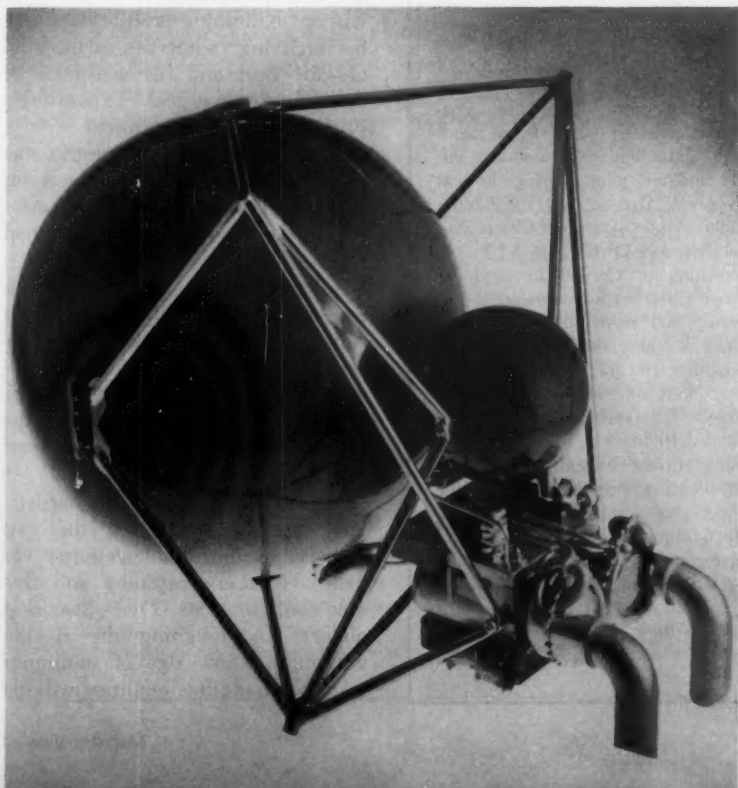
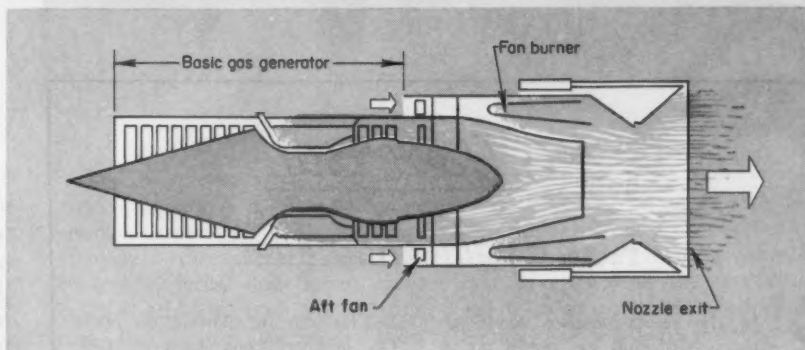
Dogpower is being replaced for winter tundra travel by snowmobiles, which have greater speed, endurance, and load-carrying capacity. Three Sno-Travelers, built by Polaris Industries Inc., made a 1200-mile trip across Alaska in three weeks. Two of them, powered by 10-hp Kohler engines, pulled toboggans carrying a half ton each.



1.3 million lb of thrust is generated in the first Saturn test firing to utilize all eight liquid propulsion units, each rated at 188,000 lb. Saturn is the rocket booster slated to get American moon explorers off the ground.

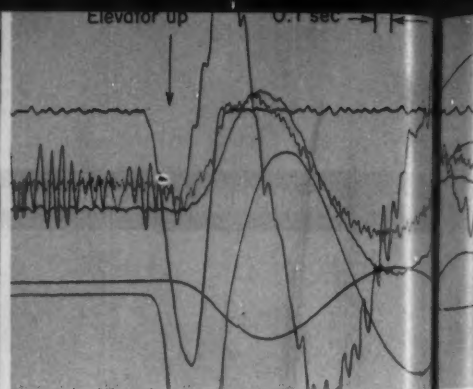
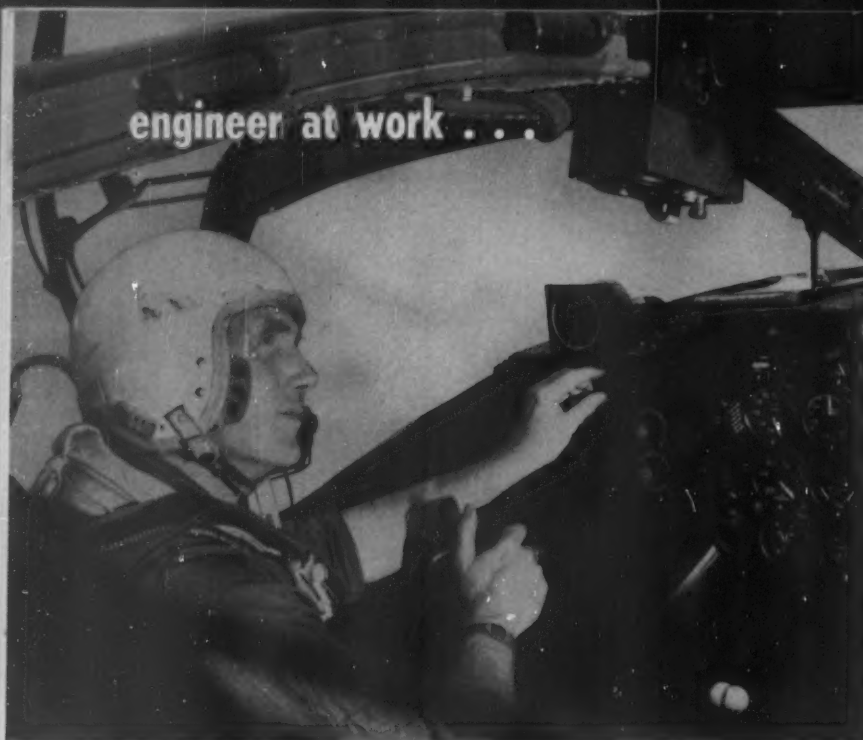


**Fan-burner engine** meets requirements of supersonic transports, according to General Electric Co. Operation of GE's aft-fan burner is similar to that of an afterburner, but more thrust is produced with the same fuel consumption and lower temperatures. Noise is also lower—one quarter that of a straight jet.



All spacecraft power, except for propulsion, plus cooling for structure and crew, will be supplied by this integrated liquid hydrogen system. Expansion of hydrogen (stored at  $-419^{\circ}\text{F}$ ) absorbs heat in cooling loop; ducted overboard through a multiple re-entry turbine, hydrogen then generates secondary hydraulic and electrical power for flights up to 14 days' duration. The system was developed for vehicles such as Dyna-Soar by AiResearch Mfg. Co. Div., Garrett Corp.





...project

## Black-

Name Gifford Bull  
Title Engineering Pilot

In the record-conscious world of aviation, Giff Bull has carved out a questionable niche of his own: He enjoys the distinction of having logged more hours of stalled flight than any other pilot in history.

His preoccupation with undesirable portions of the flight regime has not been without purpose, as evidenced by the attention of many responsible officials in commercial and military aviation. The fact that his research is usually based on actual flight, rather than on wind-tunnel test or mathematical approximation, is particularly appealing to the experts.

Preferring the title "engineering pilot" to test pilot, Giff can be described as being fairly representative of the new generation of test pilots. In place of the classical Hollywood philosophy (characterized by screeching terminal dives with the object of separating the airplane from its wings), the engineering pilot concentrates on more refined and subtle aspects of flight. Often designing his own instrumentation, he also embellishes the test results with somewhat more knowledgeable interpretations than were

called for from the old-time hot pilot.

On another score, however, Giff qualifies in the old tradition: He has the required long, varied, and sometimes colorful career in aviation. Starting his flying career at the age of 13, he acquired a commercial license at 17, and while in college (M.E., Cornell, '42), was employed by a major aircraft-engine builder as a student engineer and test pilot. During the war years (WW II), he flew the China-to-India cargo route for China National Aviation Corp.

Returning to Cornell in 1948, he received a Masters in Aeronautical Engineering and stayed on at the university's Buffalo laboratories as project engineer and pilot on various projects concerning airplane handling qualities. This included a long stint on stalled flight.

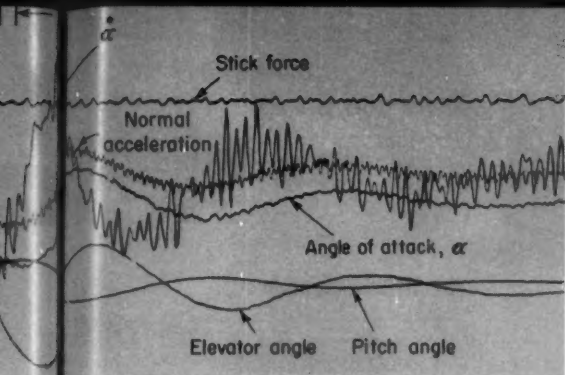
Giff's current assignment at CAL involves many exacting hours in the air, jockeying a modified World War II B-26 through various meaningful maneuvers—invariably flying under some serious, but self-designed, handicap. Significance of the job is highlighted on these pages.

AIRCRAFT design, from the standpoint of stability, is a continuing series of compromises. Plenty of stability can be built in . . . by penalizing performance; plenty of performance can be provided . . . by compromising stability. Fixing the fine line between these extremes, without building a prohibitive number of flying prototypes, is the goal of Giff Bull and his associates at Cornell Aeronautical Laboratory's Flight Research Department.

Why the profound interest in stability when extensive research on manned aircraft appears to be nearing an end? There are two good reasons:

- Information obtained by the CAL researchers may help tame (with suitable hardware) today's high-performance aircraft.
- Test results will certainly be applicable in the design of future supersonic passenger jets and manned re-entry vehicles.

The research should be particularly useful in bridging the gap between uncontrollable re-entry vehicles (Mercury capsule) and flyable configurations (Dyna-Soar skip glider). In designing the flyable version, a knowledge of minimum tolerable handling qualities will be



Time history of a disturbed airplane is portrayed by these traces recorded during CAL flight tests. In this instance, the stick was suddenly pulled back and released. Motion, forces, and control action are plotted, giving a graphic picture of the way the B-26 returns to level flight.



# Box Flight

*Exploring the ragged edge of stability*

of prime importance if the vehicle is to be kept as "clean" as possible.

CAL researchers are studying this type of problem with an unusual stable of variable-stability aircraft. Ranging from World-War II bombers to modern jet fighters, these "rubber" planes can be radically changed in mid-flight at the turn of a dial. Through the medium of electronics, fuselages can be lengthened or shortened, control surfaces altered in size.

Typical of the aircraft is a recently rubberized B-26. One set of controls in the cockpit has been mechanically disconnected from the control surfaces, and servos have been attached to both the controls and the control surfaces. Strain gages, mounted on the craft's control column, convert pilot-applied forces to electrical signals which actuate the servos. Control surfaces thus move through a distance proportional to the force the pilot has

exerted.

With control characteristics variable, signals from other sources (an angle-of-attack vane, for example) can be applied to the servos, and the B-26 can be made to adopt any number of distinct stability and handling peculiarities. In one recent test, the craft was electronically endowed with a prominent trait of swept-wing aircraft: The tendency to "Dutch roll" (a wallowing motion during which the aircraft rolls

## AIRCRAFT STABILITY (layman's definition)

An airplane can move forward, sideways, and up-and-down. It is also capable of rotation about axes in each of these three directions (from whence come pitch, yaw, and roll).

For the relatively mild maneuvers found in ordinary flight, these six degrees of freedom can be separated into two characteristic classes: Longitudinal and lateral.

Longitudinal motion includes translational motions along the fore-and-aft and the vertical axes of the airplane, as well as rotation (pitching) about the axis along the wingspan.

Lateral motion includes translational

motions along the spanwise axis (side-slip) and rotation about the fore-and-aft and the vertical axes (rolling and yawing).

Stability is defined as the way these motions die out with time if the pilot does nothing to correct a disturbed maneuver. For convenience, stability is broken down into static and dynamic considerations:

- Static stability describes the tendency of the aircraft, once disturbed, to return to its original flight condition.
- Dynamic stability deals with the time-varying motions which occur dur-

ing the return to normal (rate of decay, or build-up, of oscillatory motion).

Because of the number of variables determining overall stability, specification of satisfactory aircraft handling qualities obviously becomes complex. Purpose of the variable-stability airplane is to ease the job for the designer. It permits the translation of qualitative requirements of pilots into quantitative design recommendations . . . and it gives a preview of how predicted unconventional characteristics of future aircraft will be received by pilots. These are critical problems in military and commercial aviation.



Flying is only part of the job expected from today's test pilot. CAL's Bull logs plenty of hours in the air (often stalled, above), but for each hour of flying, he spends many more hours in determining what he accomplished in the wild blue yonder. He also designs and calibrates some of the instrumentation involved (above, left) and may even have a hand in aircraft modification.

right and left around the longitudinal axis while yawing right and left around the vertical axis).

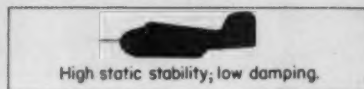
To simulate this quirk, signals proportional to sideslip angle (from a yaw vane) are fed to the rudder servo, and the normal period of the Dutch roll oscillation for the B-26 can be changed to make the maneuver slow and ponderous or quick and snappy. If a signal proportional to rate of turn is added, the damping is changed, and the motion becomes either very oscillatory or very well damped. Furthermore, suitable addition of the signal from the yaw vane to the ailerons will vary the amount of rolling motion

which occurs in the Dutch roll, so either a flat, tail-wagging motion similar to that of the DC-3 in rough air can be simulated, or the large amount of rolling associated with the Boeing 707 (with yaw damper off) is obtained.

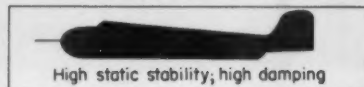
All of these gyrations are initiated (or suppressed) by the servos attached to the control surfaces, not by the servos driving the pilot's controls. As far as the pilot of the variable-stability aircraft is concerned, his controls feel perfectly normal, and aircraft response is not "artificial."

For safety's sake, servo force is limited, making it impossible to ob-

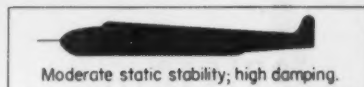
At the twist of a dial . . .



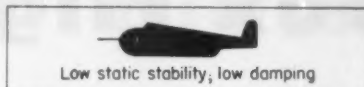
aircraft configuration . . .



and thus stability . . .



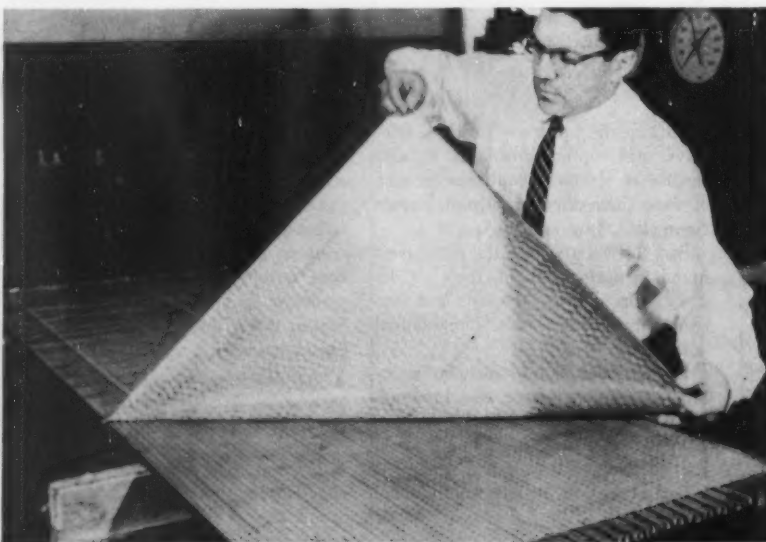
are altered in mid-flight.



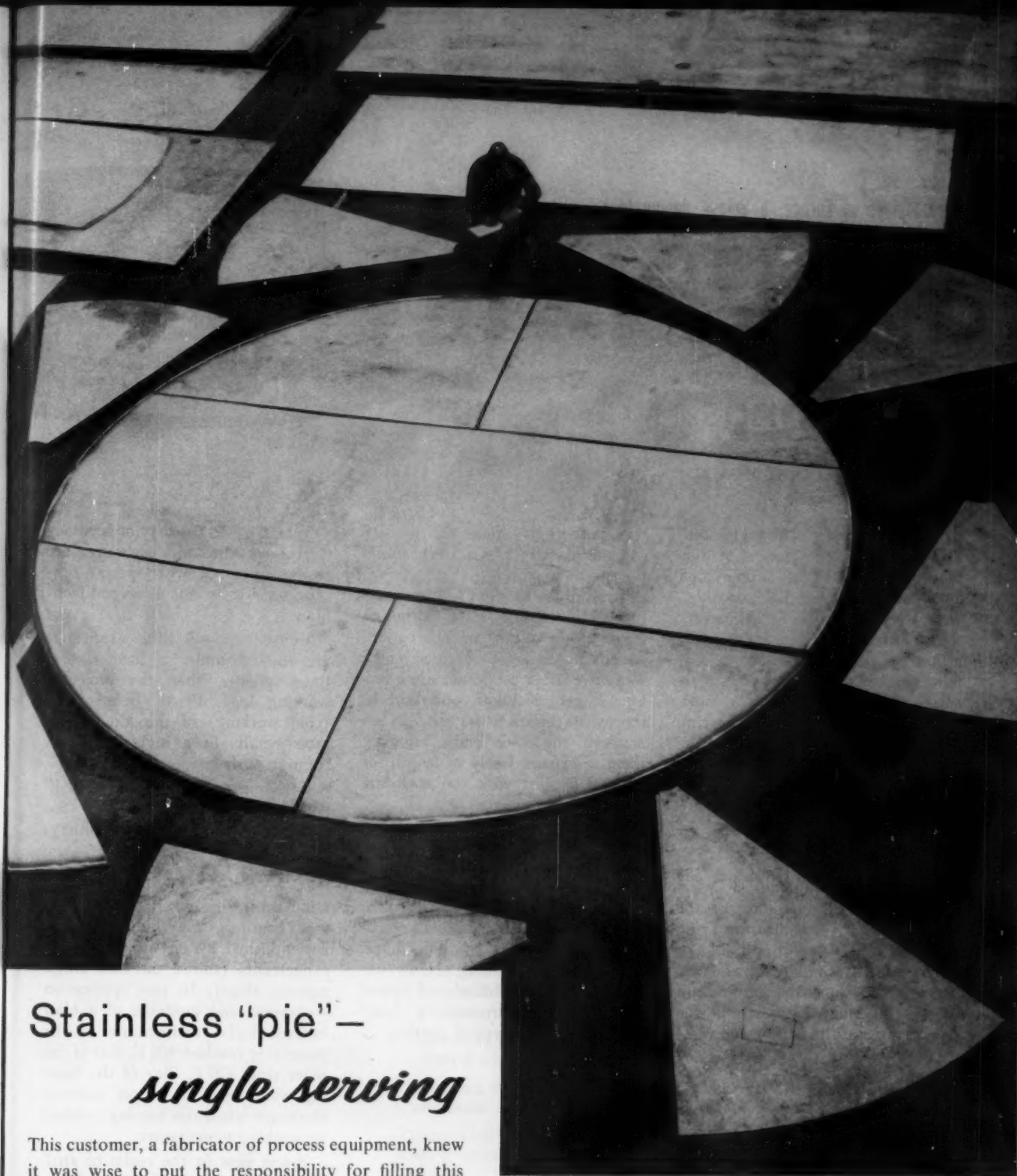
tain control deflections which would produce load factors greater than the structural limits of the aircraft. In addition, the safety pilot (in the co-pilot's seat) has the usual set of flight controls in front of him and, at the flick of a switch, can restore the variable-stability aircraft to its normal behavior in event of emergency.

## Quick-Setting Magnetic Liquid Spots Weld Deficiencies

Intricate weld patterns can be completely and accurately inspected with a plastic sheet that shows defective welds, inclusions, and other flaws. Solutions that contain magnetic particles and set up in as little as eight minutes have been developed by the Instruments Div., Budd Co., Phoenixville, Pa. Poured or sprayed on the surface of a part, magnetic particles in solution migrate to show the defects; when the film sets, it can be stripped off. The magnetic-particle pattern, frozen in place, gives a permanent record. Marketed under the name Recordflux, the system has been used to nondestructively test diameters of spot welds in stainless-steel sandwich.







## Stainless "pie"— *single serving*

This customer, a fabricator of process equipment, knew it was wise to put the responsibility for filling this stainless steel order in the hands of a single producer—G.O. Carlson, Inc. He knew that our specialists, working with modern equipment, would make each item of the order "to specification." And he also knew that our delivery promise is a trust that we fulfill.

For your order—or orders—of stainless steel plate and plate products, come to Carlson. Here skilled men, working with the finest equipment, are determined to match your every wish.

**G.O. CARLSON** *Inc.*  
*Producers of Stainless Steel*

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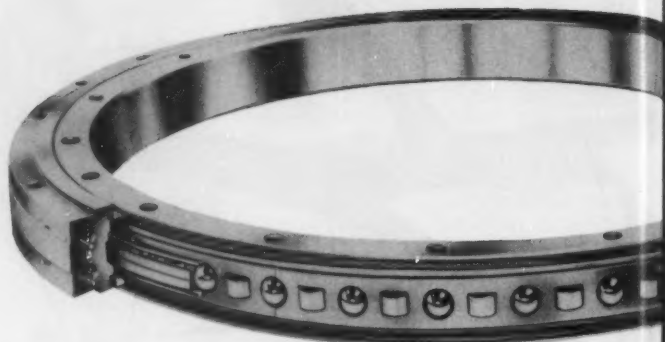


PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES •  
BARS AND SHEETS (No. 1 Finish)



Commonplace in Europe, a unique design idea has been overlooked almost completely in this country:

## Wire-Race Bearings



**F**EW designers would argue with the quality, convenience, or durability of a packaged, off-the-shelf antifriction bearing. But for those who have need of a split ball or roller bearing, and make do with a journal, or where other special mounting forms or running characteristics are necessities, a newcomer to the low-friction bearing field may be the answer. Called the wire-race bearing, it has long been a familiar component in Europe and may soon be available here.

### **The whole idea . . .**

(and the big advantage) of wire-race bearings is separation of the raceway from the bearing ring (they're not integral). Balls or rollers run on circular wires (two, like a track) inserted in grooves in the bearing rings. This permits the use of different materials for race-

ways and rings—materials that are compatible with the different functions of these parts.

Typically, raceway wires are high-grade spring steel, although plastics, aluminum, or other non-ferrous materials may be used where weight or other properties are a factor. A gap of about one-third of the wire thickness is usually left between the wire ends, allowing them to expand freely in length for optimal contact with the enclosing bearing ring.

Bearing rings are usually fabricated from tough unhardened steel. Since they are never in contact with rolling elements of the bearing, they don't require heat treatment after finish machining, will accurately hold their original shape. Furthermore, the ring, being unhardened, can be drilled and tapped for mounting purposes, or "cut" with almost any type of gearing.

Where added capacity or accuracy is required, the wire raceways are easily contoured with special running surfaces by one of several techniques:

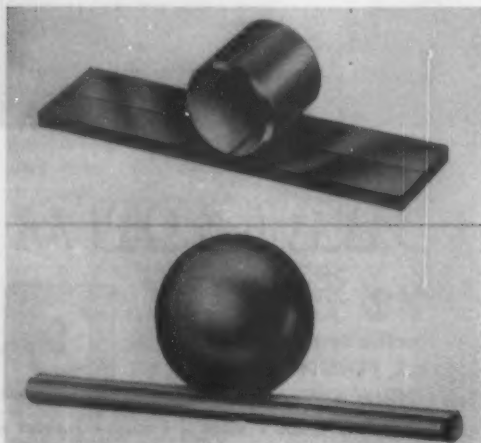
- **Running-in** — Rolling elements are rotated under a load several times greater than the projected working load. Plastic deformation (cold working) of the tough wire races results in a highly polished running surface.
- **Grinding** — Races can be "fitted" with any desired curvature by the use of special grinding machinery.

### **Play is adjustable . . .**


and "splits" are possible with wire-race bearings. Play adjustment is accomplished by one of several arrangements (shims, threaded rings, tapered rings). In one application — support and guidance of a blast furnace bell — temperature of the inner ring reached 400 F, that of the outer ring, 100 F. Play of the bearing was preset for proper running clearance when the bearing reached its working temperature.

Brand new in the realm of antifriction bearings is the "split" option offered by wire-race units. The bearing can be assembled around a shaft because of the insertable feature of the wire raceways. Load capacity is admittedly lowered in some cases by splitting, but this method does make it possible to use antifriction bearings where they have never ventured before.

With all wire-race bearings, the fact that races are separate items



**Flat wire for rollers, round** for balls, form the raceways in a versatile new (to the U. S.) family of low-friction bearings. Because of their unique capabilities, wire-race bearings may open the door to design on completely new principles.

Another  Test System at work...



*A Magnaflux Type "N" Test Unit used for checking the quality of all chemical and medical tablet press punches at the Arthur Colton Company.*

**8 Out of 10 Plants  
Need Only this One Unit  
to Handle All Magnetic  
Particle Testing**

After an industry survey, Magnaflux has engineered a single test unit versatile enough to handle *all* magnetic particle test requirements in 8 out of every 10 plants. The new Type "N" Test Unit (A.C. or D.C.) locates cracks in parts up to 24 inches long, 10 inches in diameter. It is equally efficient whether you test many different parts or a few standard parts at high volume and speed.

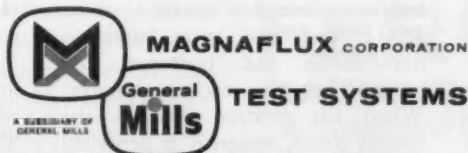
Infinitely variable current output assures optimum control for each test need.

Standard adapters and jigs, automatic magnetization and processing, even conveyORIZED handling, at small extra cost.

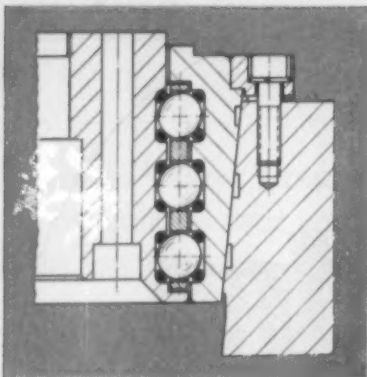
Optional coil provides simultaneous circular and longitudinal magnetization—doing the work of two units.

Grouped controls speed operation—standing or sitting.

Phone our local Field Engineer or write Magnaflux Corporation, 7334 West Lawrence Avenue, Chicago 31, Illinois.



MX Test Systems include MAGNETIC PARTICLE, FLUORESCENT PENETRANT, THERMOGRAPHIC, EDDY CURRENT, ULTRASONIC, STRESS ANALYSIS, GAMMA RAY SERVICE, DYE PENETRANT & MAGNETIC FIELD



**Tapered ring permits play adjustment** in one version of the wire-race bearing. Proper "setting" can thus be accomplished in the field to suit running conditions and environmental factors.

means easy restoration of the bearing to "as new" condition by the comparatively simple and low-cost procedure of replacing wire inserts.

#### **Size, shape, and performance . . .**

of wire-race bearings pretty well cover the field. The bearings are being used in the optical industry and in steel mills. Diameters range from 1 in. to more than 15 ft; relative rotational speeds of 80 to 100 ft per sec are permissible. Accuracies achieved are on the order of 0.0005 in. maximum radial and axial run-out (for bearings up to 7 ft in diameter). A full selection of bearing types is thus available (including combined ball and roller

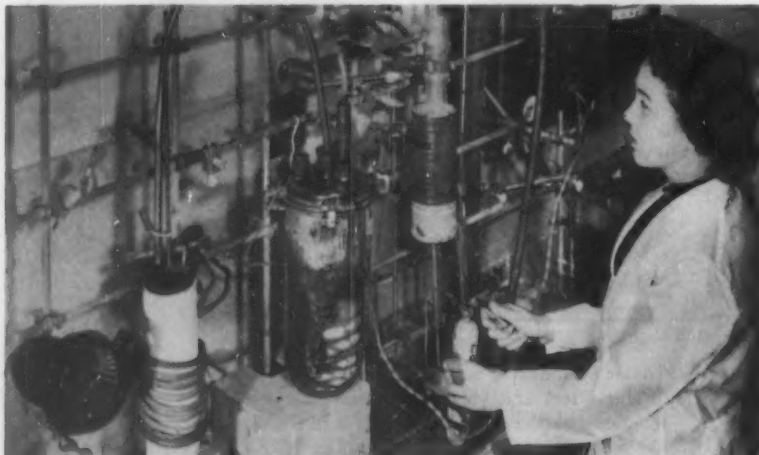
configurations) classified in much the same manner as conventional anti-friction bearings.

Because most wire-race bearings are designed to carry radial, axial, and tilting load simultaneously, bearing arrangements which ordinarily consist of several conventional bearings often can be replaced by one wire-race assembly.

#### **Coming . . .**

in a future issue of **MACHINE DESIGN**: A detailed guide to design with wire-race bearings. The article will be bylined by Bernhard J. Braun, who also supplied the information for this news report.

## **Vapor Plating Broadens Future for Tungsten**



**High-purity tungsten** is plated on a hot base material when hydrogen and tungsten tetrafluoride are injected into the reactor (ceramic cylinder, left). Hydrogen fluoride, the only by-product, is absorbed in a trap (vessel in center). Samples of the end products include a plated rocket nozzle and a

plated cross section of a rocket nozzle (bottom row). After plating, the base material can be chemically dissolved if a pure-tungsten part is wanted. Sample parts shown are: Component for an electron furnace (upper row, left), and rocket-nozzle insert (upper row, right).



WASHINGTON—Tungsten may soon live up to its space-age potential. National Bureau of Standards researchers have bypassed machining problems (due principally to brittleness and hardness) and found a way around the weight restrictions that have barred tungsten from many aerospace applications. The answer: Plate it on a base material with a new vapor-deposition process.

The technique makes tungsten practical as a hard, corrosion-resistant, high-temperature shield material. It melts at about 5685 F, and it's one of a few materials with significant structural strength above

3600 F. It can now be plated on molybdenum (for example) to form a strong, lightweight structure, and if a very thin tungsten shield is acceptable, the base metal can be chemically dissolved.

The object to be plated is placed inside a ceramic cylinder and air is pumped out and replaced with hydrogen. It is then heated to about 1200 F and two gases, tungsten hexafluoride and hydrogen, are pumped into the reaction chamber. When the mixture contacts the heated object, tungsten is deposited on the hot surface. Hydrogen fluoride, the by-product, is absorbed

in a trap. Deposits 1/16 in. thick can be obtained in one hour.

The tungsten deposited is purer than commercial grades. Silicon is the only impurity present in a concentration of 0.1 per cent or more. Density is higher than that produced by powder metallurgy or flame spraying because plating eliminates the very tiny holes that result from the other two processes.

Adhesive bond to molybdenum and nickel is good; to copper, somewhat weaker; to iron, rather poor. Tungsten-graphite bond is as strong as the graphite itself, and bond to ceramics is also good.

# How INDEX TABLE *DESIGN* affects INITIAL PRICE and TOTAL COST

Study these drawings to see how the design of an index table affects total costs of an installation. Some tables may be priced lower than others initially, but the additional charges for auxiliary items to adapt them to production requirements, added to maintenance and downtime costs, can make a drastic difference in the **total price**.

The Ferguson Intermittor, indexed by a roller gear drive which operates a minimum of 8,000 hours at speeds up to 2,000 indexes a minute without maintenance, needs no aux-

iliary locking. It is designed for high speed operation and incorporates rigid integral supports for tooling to eliminate expensive segmental components. The Intermittor dial is supported by tapered roller thrust bearings to withstand heavy loads with little friction. A stationary center tooling support is held rigidly at its top by anti-friction radial bearings and at the bottom by a flanged base bolted to the housing. Hollow center of the support may be used for passage of coolants, fluids, air or vertical shafts to transmit motion to the work surface.

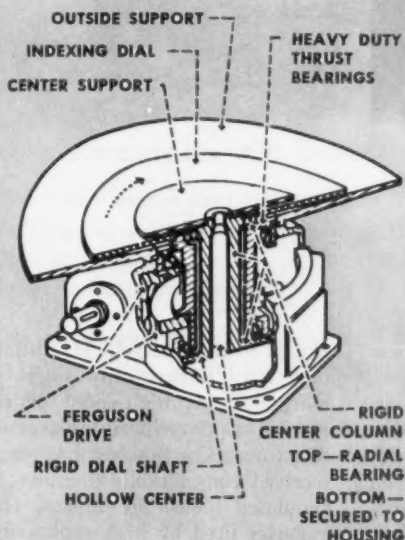


FIG. 1—FERGUSON INTERMITTOR

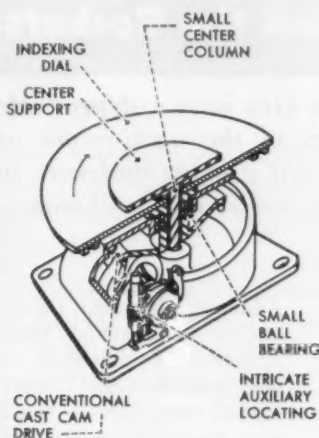


FIG. 2—BARREL CAM TYPE

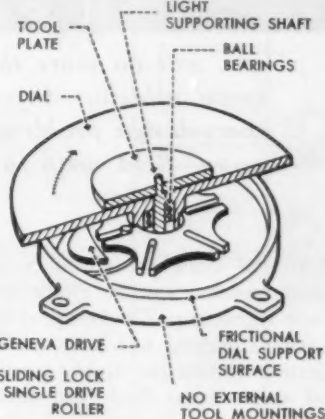


FIG. 3—GENEVA DRIVE TYPE

Figures 2 and 3 show typical barrel cam and geneva drive index tables. Their indexing mechanisms limit operating speeds, therefore other components may be "designed down." Shafts and bearings are lighter; frictional support surfaces might be employed instead of thrust bearings and an auxiliary locking or locating device is a costly necessity for even modest accuracy requirements. Tool mounting methods are often provided at additional expense and sometimes even ignored. Difficulties of installation and frequent maintenance downtime can increase total cost drastically.

## • SEND FOR CATALOG

Many other advantages result from the selection of a Ferguson Intermittor. Compare designs in new Catalog No. 160 which contains data on more than 175 standard tables. Every design engineer should have a copy. Get yours by writing:

# FERGUSON MACHINE CORPORATION

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7818 Maplewood Industrial Court  
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## Research Behind the Rockets

*... will do more than give man a dependable space vehicle. Answers to the next round of space-design problems will provide designers in every field with new tools and techniques.*

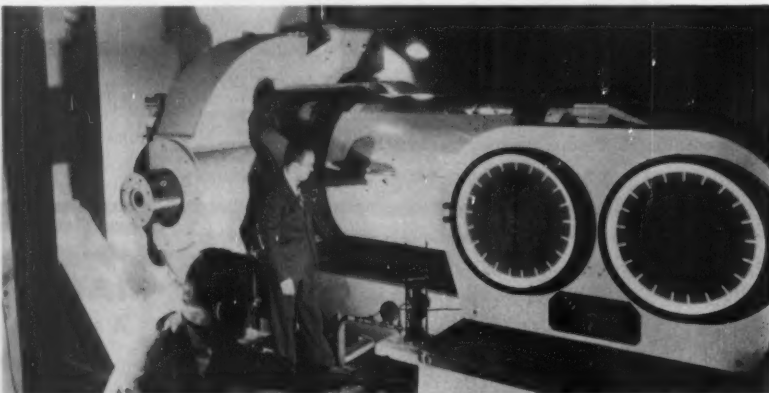
YEARS of work are ahead before planet travelers can be guaranteed a safe round trip. Obviously, much of what's learned will have no application outside the highly specialized space-design field. But many answers will spill over into other areas of engineering, filling gaps in existing data and extending concepts in general use. Researchers at the National Aeronautics and Space

Administration are planning new studies on material fatigue, performance of thin-shell structures, and pressure-vessel theory. These studies seem sure to shake up design theory across the board; even such traditions as "factor of safety" and "optimum design" may be overhauled.

Meteoroids will probably be the principal cause of structural catas-

trophe to a space vehicle. Although they may impart only slight primary damage, high-speed penetration of a propellant tank can be disastrous. The problem has already received considerable attention, and simulated meteoroid impacts (from particles fired by high-explosive accelerators and other equipment) have turned up hints on how to minimize the danger. However,

**Structural materials** are tested to failure in this NASA combined-loads testing machine. Fatigue studies are also highly important in space-vehicle development because, unlike aircraft fatigue, periodic inspections of the vehicle can't substitute for uncertainty of design. Knowledge gleaned from the space program is expected to influence many unrelated design areas.



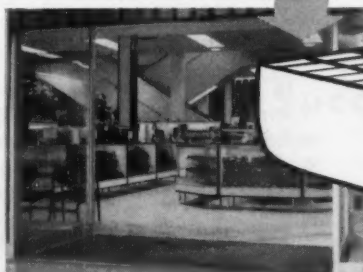
**WHY MR. ERNEST GYGAX,**  
**Chief Engineer for**  
**American Air Curtain Corporation**  
**SPECIFIES 'BUFFALO' BLOWERS**



**HOW AMERICAN AIR CURTAIN DOOR WORKS:**

Directional nozzles send air downward from ceiling of entrance. Air passes across entrance and is drawn through a floor grill into a pit. From pit, the air passes through filters and a heating element. A blower then directs the air upward to the nozzles to repeat and continue the cycle.

Like Mr. Gygax, you can depend on 'Buffalo' Engineers for complete cooperation and expert advice in your special design problems. And like Mr. Gygax, you can rely on 'Buffalo's' 83 year reputation for quality — in engineering, construction and service. Contact your nearby 'Buffalo' Representative. He'll gladly help you solve your air moving problems. Or write us direct.



**AIR HANDLING DIVISION**  
**BUFFALO FORGE COMPANY**  
 Buffalo, New York

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.



'Buffalo' Air Handling Equipment to move, heat, cool, dehumidify and clean air and other gases.



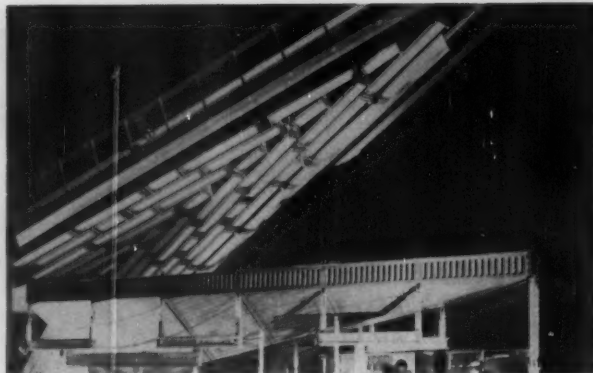
'Buffalo' Machine Tools to drill, punch, shear, bend, slit, notch and cope for production or plant maintenance.



'Buffalo' Centrifugal Pumps to handle most liquids and slurries under a variety of conditions.



Squier Machinery to process sugar cane, coffee and rice. Special processing machinery for chemicals.



A quartz-lamp inferno simulates re-entry conditions for a full-scale section of a proposed space glider (above). The experiment is part of a deformation study set up to extend known structural properties of different materials. Because thin-wall structural behavior under long-term heating is not well understood, test methods must be developed to evaluate different loadings. Impact studies (left) help predict meteorite damage to space vehicles. Minute particles, propelled against the model by a high-explosive charge, penetrate it and provide damage data for researchers. While puncture of propellant tanks would be a serious matter, thin-film structures (left) might weather the attack.

penetration experts disagree on detailed designs, and many questions must yet be answered.

#### **Skins for Spacecraft**

Space vehicles will be built as thin-shell structures (to keep weight down), but the behavior of such shells is not well explored, particularly for radius-to-wall-thickness ratios that exceed 1000. Present theories for concentrated or line loads are unproven for thin shells, and test methods that will evaluate the effects of these loads do not exist.

Because missile-shell thicknesses have decreased steadily as high-tensile materials became available, failures are often due to buckling; i.e., the critical factor is now compressive loading. Honeycomb structures with expanded cross sections increase bending stiffness in weak regions, but this approach is still relatively untested.

Little work has been done on multiwall pressure vessels, although they're likely candidates for spacecraft. Thin multiwalls would slow down meteorites by stages and would provide radiation protection. As long as one surface remained intact, the cabin would not leak away its precious atmosphere.

Most current design concepts for pressure vessels are at least 50 years

old. Operating stresses are limited to a fraction of actual yield strength, and liberal factors of safety compensate for inaccuracy and ignorance. Fresh studies of pressure-vessel theory must re-examine the fundamentals.

#### **Lessons from Space Fatigue**

Designers in many fields, hampered by lack of reliable data on fatigue, rely on generous factors of safety. Aircraft designers are restricted by weight limits, but they also have a way out: They know that regular inspection will take the place of design certainty to some extent. In spacecraft, however, reliability is mandatory. There will be no opportunity to observe incidence and growth of cracks, and the designer must meet fatigue problems on the drawing board.

No satisfactory method of predicting fatigue life of a vehicle is yet available, or even in prospect. Gaps exist in data on allowable design properties, and methods of applying available data have never been entirely satisfactory. Consequently, NASA is increasing emphasis on fatigue research in three areas: 1. High-stress levels. 2. Acoustic-energy loading. 3. Multiaxial tensile stresses.

High-stress levels are important

because available data are for lower levels than those a spacecraft will encounter. A ship may undergo only few cycles of stress during launch, but thermal-stress cycling seems sure to occur in flight. Weight factors require that these stresses be very close to the yield strength of the material.

Better analytical methods and techniques are needed for handling acoustic loading. This work will probably result in a better knowledge of damping and response.

Fatigue under multiaxial tensile stresses needs study. Methods for correlating uniaxial and multiaxial stresses must be developed.

#### **Real Meaning for "Optimum"**

In many companies the term "optimum design" has a stigma attached because it has been misused. Such products are often so marginal in reliability that they inevitably fail. Many times no real distinction can be drawn between an "optimum" and an "adequate compromise." Once rational principles of optimum design are spelled out and a procedure is developed (NASA is studying the problems) the pioneering work will serve as a guide to designers in other fields who can then apply the techniques to their own problems.





**Dow Corning**

# **SILICONE NEWS**

for design and development engineers • No. 76

## **SILICONES OPEN NEW MARKETS**

Silicones provide the extra measure of performance that frequently helps open new markets for established products. A good example: the air and hydraulic cylinders manufactured by Carter Controls, Inc., Lansing, Illinois.

Carter has been able to extend the serviceability range of its cylinders from a maximum of 250 F to 500 F . . . through the use of silicone rubber seals. As a result, the company now offers a new line of air and hydraulic cylinders for applications "too hot" for conventional cylinders . . . brakes or clutches, and equipment on drying ovens, heat-treating furnaces, foundry units, and plastic presses.

Because O-rings made of Silastic remain elastic — and maintain a permanent, re-



liable, tight seal at both high and low temperatures — Carter cylinders now render dependable, long term service over a broader temperature span. (Cont. Pg. 2)

## **How To Be A Successful Designer**

Develop products that exceed customer expectations. Such extra performance creates the customer satisfaction that is so necessary in building brand recognition and preference.

But how do you give your designs that all-important extra edge in performance? Using Dow Corning Silicones is one sure way — particularly if you're concerned with designing consumer products such as home appliances.

Next question: What silicones to use and how to use them to improve appliance performance? You'll find the answers to



## **FOR LASTING BEAUTY**

Eye appeal that lasts. Protection that's built-in. How do you obtain both for metal parts that get hot in service . . . space heater grilles, for example? A heat-stable silicone finish is the answer, according to Heil-Quaker Corporation, Nashville, Tenn.

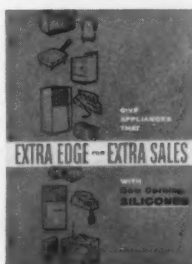
This company's "Quaker" brand of thin-line home heaters are noted for their trim, stylish appearance. Every cabinet is equipped with exclusive Sun-glo radi-

ants that cast a combination of reflected and circulated warmth through the protective shield grilles. Since these grilles are prominent in the design, their lasting "good looks" is a major requirement.

That's why Heil-Quaker design engineers specify a baked-on gold colored silicone enamel formulated by Midland Industrial Finishes, Waukegan, Ill. This rich decorator color sparks both appearance and sales! And because it's made with Dow Corning silicone resin, the finish retains its "factory fresh" look indefinitely; does not discolor, crack, or craze under heat from the radiants; shows little or no deterioration in severe life tests.

Silicone appliance finishes readily withstand temperatures to 500 F and higher, have excellent color and gloss retention. Available from leading paint formulators in a full range of colors, these coatings have proved ideal for space heaters, incinerators, oven thermostats and many other "hot" products. Other silicone-based finishes are used on food display cases, refrigerators, bathtubs and similar units where a durable, lightweight, and less-costly-than-porcelain finish is desired. No. 242

these questions are outlined and illustrated in the sparkling new Dow Corning booklet, "Extra Edge for Extra Sales." Even if you're not an appliance designer, you'll find a wealth of interesting and useful information in this colorful 8-page bulletin. Be sure to send for your informative copy today.

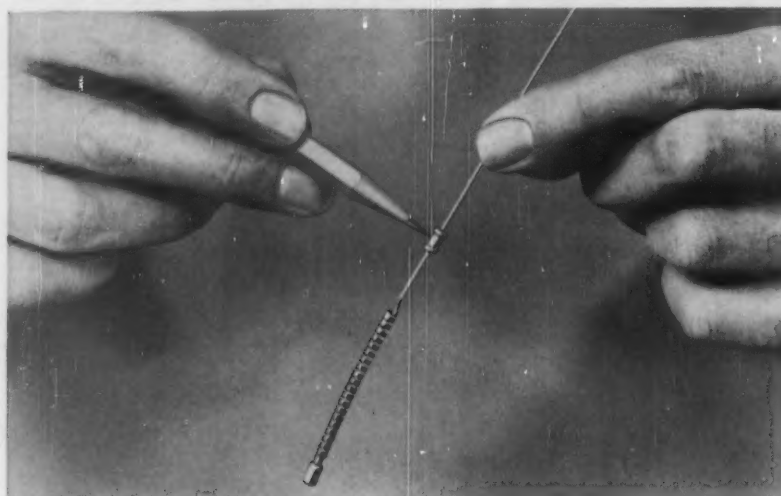


No. 241

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**MORE**





## DAMP OUT INACCURACY

Here's how silicones help damp out unwanted vibration and shock . . . improve performance over wide temperature ranges. Instrumentation engineers at the Rochester Manufacturing Company, Rochester, New York, provided this good example:

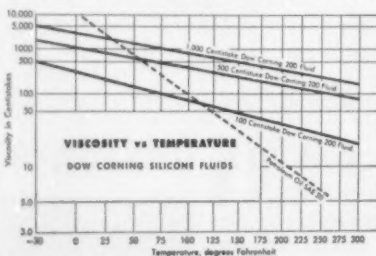
RMC produces shock and vibration resistant bimetal thermometers that are accurate within 1% over extremely wide temperature ranges. The company assures this kind of accuracy by double damping . . . coupling the effects of specially designed bearings with the uniform performance of a silicone damping fluid.

Undamped elements subjected to continuous shock or vibration have a tendency to unwind and throw the instrument out

of calibration. Damping with silicone fluid protects the thermometer's accuracy, especially in the temperature ranges up to 400 F where a very thin bimetal element is used. The silicone fluid holds the heat-sensing element in place and prevents the shifting which destroys accuracy.

In addition to assuring accurate calibration, silicone fluid damping also improves dial readings. It steadies an otherwise jittery "needle" and makes possible quick, accurate temperature readings even when vibration is severe enough to blur the outline of the thermometer itself.

The following graph shows why Dow Corning silicone fluid provides uniform damping action in this instrumentation application . . . and in numerous sensitive automotive and aircraft devices. No. 244



### SILASTIC (Continued)

Can improved performance widen the use of your product . . . open new markets? If so, it will pay you to investigate the silicone fluids, lubricants, resins, adhesives, dielectrics, rubbers, and other silicone products available from Dow Corning. A personal copy of the new *Engineering Guide to Dow Corning Silicones* is yours for the asking. Circle . . . . No. 243

## new literature and technical data on silicones

A new, ready-to-use adhesive for silicone rubber, Silastic 140 Adhesive, requires no catalyst, no premixing. It cures at room temperature to a strong, resilient bond without need of heat or pressure. Retains good bond and rubbery characteristics at temperatures ranging from -70 to 500 F. Typical properties, bond strengths, and other performance data about this new adhesive for silicone rubber are available. No. 245

Meet today's electronic needs: Dow Corning Silicones enable electronic equipment and products to meet today's tougher performance requirements . . . make possible new designs. How to achieve miniaturization, better environmental protection, and assure performance on demand is outlined in a new *Electronics Engineers' Guide to Silicones*. In addition to application illustrations, this guide contains processing information and engineering data . . . leads to the selection of silicones that'll best withstand heat, corona, voltage stress, mechanical stress, chemical attack, moisture, fungus and fire. No. 246

ABC's of Defoaming — The literal ABC's to fast antifoam action are compiled for you in a new comprehensive brochure on Dow Corning silicone foam suppressors. This 8-page booklet gets down to cases showing how these versatile antifoam agents are actually reducing maintenance time . . . processing time . . . costs . . . while increasing production capacity . . . efficiency . . . economy. This new manual on foam control in the processing of chemicals, food and drugs, petroleum and asphalt, paper and textiles, as well as in laboratory work and the metalworking industries is available for your files. Circle . . . . No. 247



Stator Encapsulation — A manual of procedure-to-follow details how to encapsulate stator windings of random-wound induction motors with Silastic RTV, the Dow Corning silicone rubber that vulcanizes at room temperature. A ten-page, illustrated instruction sheet also outlines the advantages of this silicone protection, and gives specifics about the materials, procedure, details, and typical properties you will want to be familiar with! No. 248

Dow Corning Corporation, Dept. 4908, Midland, Michigan

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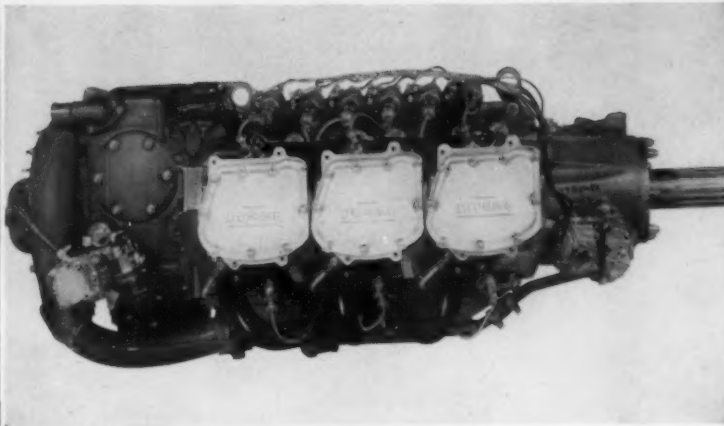
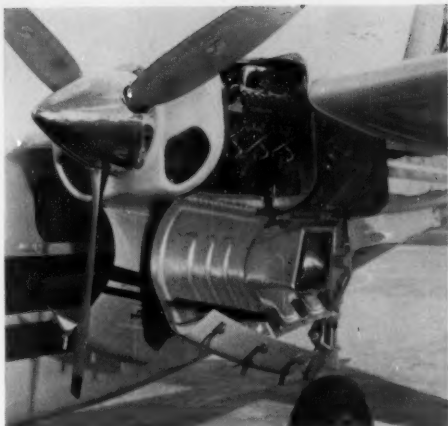
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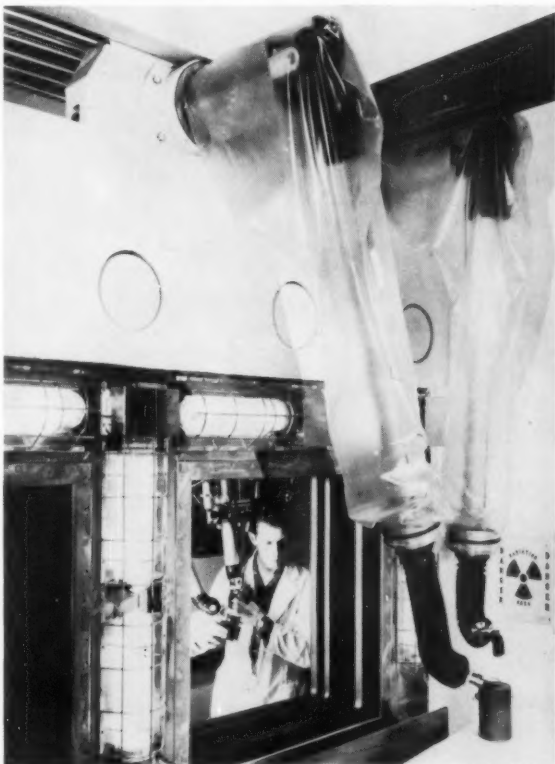


## Business Planes Get Fuel-Injection Engines

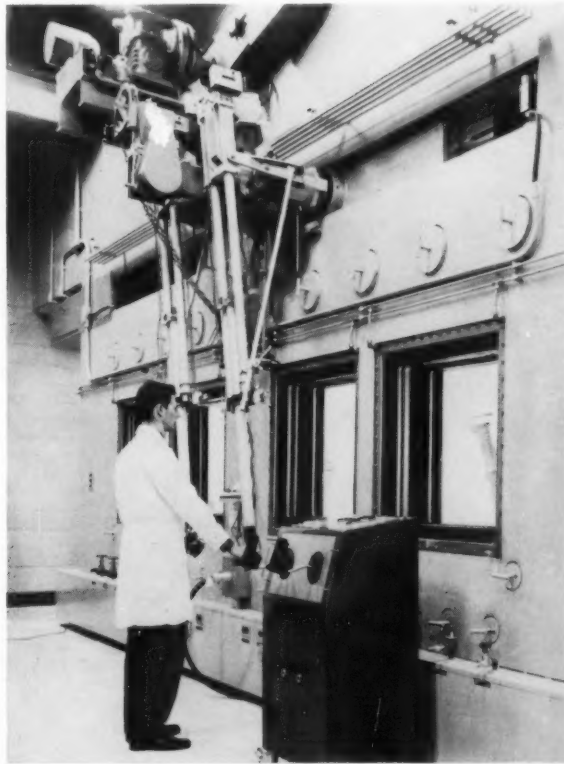
Airfoil-shaped nacelles cut engine drag almost in half on a new series of Aero Commander utility aircraft. Three versions of a fuel-injection engine will power these airplanes, marking the first appearance of the type in the business-airplane field. Designed by Lycoming Div., Avco Corp., direct-drive and geared-and-supercharged versions have already received

FAA certificates. A geared-drive model, still under test, will round out the series. Advantages of the new powerplant include greater horsepower, smaller size, and quieter operation. An advanced tuned-induction system should lead to greater fuel economy, and a new exhaust system (ports are located on top of the engine) eliminates augmentor tubes.

## Physicists Grow a Longer Arm



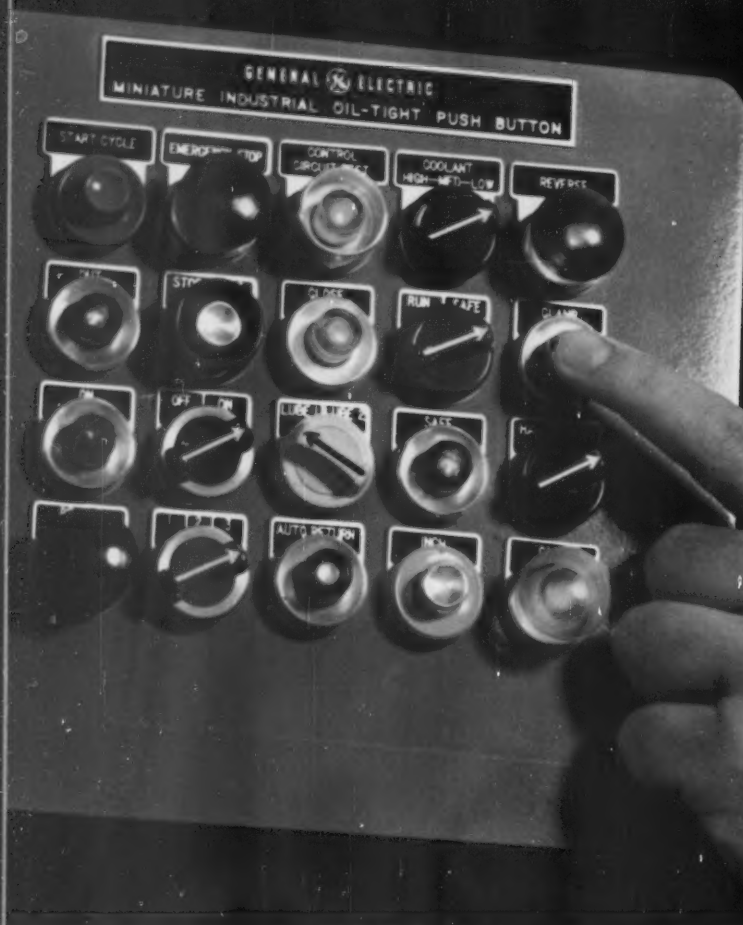
Telescoping blocks of steel shielding will greatly extend the working areas within two new hot cells now nearing completion at the AEC's National Reactor Testing Station. Designed to slide back and forth and keep even a single beta particle from escaping, the shields permit technicians to move master-slave manipulators along a wall. Control arms for the robot-like hands pass from "cold" side to "hot" side through sealed openings in a traveling block of



6-in. thick steel. When the manipulator is moved and the block slides, a staggered row of five overlapping shields—each on its own V-shaped rail—travels at carefully synchronized speeds, telescoping together or sliding apart. Physicists claim that the innovation will permit remote-controlled tests nearly anywhere within the 400-sq ft cells. Designer and fabricator of the new shielding system is Paul Robbins Machine Shop, Pocatello, Idaho.

# New

## Another Measurable Advantage from General Electric Control



New CR104 push buttons help improve your machine appearance, cut your panel space at least 40%.

## FIRST COMPLETE LINE OF INDUSTRIAL MINIATURE OIL-TIGHT PUSH BUTTONS

- Push buttons • Selector switches
- Illuminated push buttons • Indicating lights
- Push-to-test lights

Now you can design entire panels with miniature pushbutton units and cut your panel space requirements at least 40 per cent! General Electric announces the development and immediate availability of industry's first complete Industrial Miniature Oil-tight Pushbutton line.

This new CR104 line offers you the operating and functional units presently available in heavy-duty oil-tight forms—with an attractive appearance that enhances the design of your machines. A wide variety of operators is available, plus various modifications, special units, and nameplates to meet every

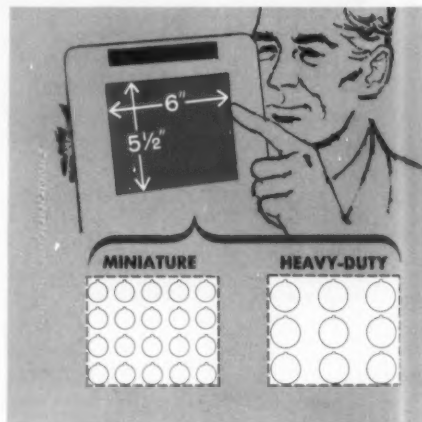
operating requirement. Color coding is available in both operators and rings to provide you the flexibility of many different color combinations. Also, enclosures and pendent stations are available to accommodate from four to 42 units.

**FOR MORE INFORMATION** on this outstanding new development in control—and the "measurable advantages" it offers you—contact your nearby G-E Apparatus Sales Office, or write for Bulletin GEA-7127, General Electric Co., Schenectady 5, N. Y.

811-10

You get

**MEASURABLE ADVANTAGES**  
WITH GENERAL ELECTRIC CONTROL



**GENERAL  ELECTRIC**

**SAVE PANEL SPACE.** Twenty new General Electric miniature units fit into the exact space required for nine heavy-duty oil-tight push buttons.



Going to the ...  
MACHINE TOOL EXPOSITION?



You Can See ...

**THE COMPLETE NEW LINE OF  
GENERAL ELECTRIC INDUSTRIAL  
MINIATURE OIL-TIGHT  
PUSH BUTTONS ACTUALLY  
INSTALLED ON MACHINES**

**GENERAL ELECTRIC BOOTH**—You can get complete information on the new G-E CR104 line of Industrial Miniature Oil-tight Push Buttons by visiting General Electric Booth #112 at the Production Engineering Show, Chicago's Navy Pier, Sept. 6-16.

**SEE INSTALLED UNITS HERE**—Also, no less than 28 of the machine tool industry's leading manufacturers are exhibiting new machines which feature these General Electric industrial miniature oil-tight units at their booths in the Chicago Amphitheatre. They include:

Atlantic Machine Works, Booth 543  
Avey Drilling, Div. of Match & Merryweather, Booth 822  
Barber-Colman, Booth 923  
Buffalo Forge Company, Booth 551

Chas. G. Allen Co., Booth 148  
Cincinnati Milling Machine Co., Booth 1034  
Cleereman Machine Tool Corp., Booth 632  
Cone Automatic Machine Co., Booth 1215  
Dennison Engineering Division, American Brake Shoe, Booth 914

DeVlieg Machine Co., Booth 431  
Edlund Machinery Co., Div. Harsco Corp., Booth 531  
Ekstrom Carlson and Co., Booth 846  
Fellows Gear Shaper Co., Booth 929

Fosdick Machine Tool Co., Booth 800  
Gardner Machine Co., Booth 811  
Giddings and Lewis, Booth 1320  
Giddings and Lewis/Bickford, Booth 1320  
Heald Machine, Booth 924

Lucas Machine, Div. of New Britain Machine Co., Booth 838  
Kearney & Trecker, Booth 1008  
R. K. Le Blond, Booth 810 and 908  
Michigan Tool Co., Booth 945

Nebel Machine Tool Corp., Booth 1319  
Niagara Machine Tool Works, Booth 1330  
Rivett Lath & Grinder, Booth 1210  
Sidney Machine Tool Co., Booth 1440  
Sundstrand, Booth 1014  
Warner and Swasey, Booth 451

Before you leave the show make sure you've seen industry's first complete line of industrial miniature oil-tight units. Your General Electric sales engineer will be glad to provide you with more information. Contact him or write General Electric Co., Section 811-11, Schenectady, N. Y.

*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**

Circle 418 on Page 19

## Citizens' Moon Bounce Succeeds



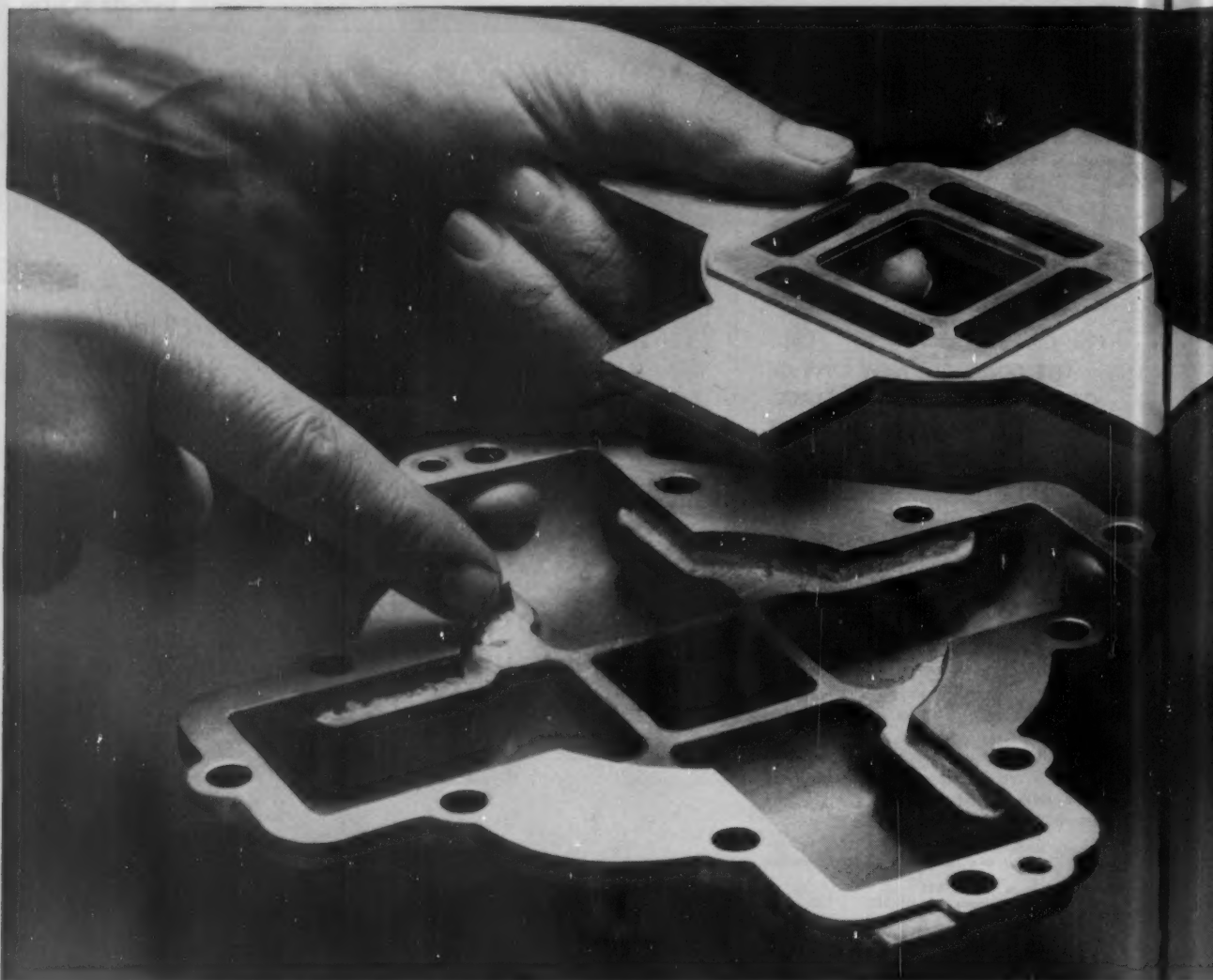
The first amateur moon-bounce radio communication marks a milestone in the development of amateur radio. Contact was between members of the Eimac Radio Club, San Carlos, Calif., and Mr. Sam Harris, Rhododendron Swamp VHF Society, Medfield, Mass. Months of effort by the amateurs were climaxed when microwave signals were transmitted in both directions on 1296 mc on July 17. The equipment was refined and the first successful two-way communication was made on July 21 between 7:30 and 8 a.m. Pacific Daylight Time. Both ham sets used a 1000-watt klystron in the transmitter and a Microwave Associates MA2-1000 parametric amplifier in the receiver. The only other moon-bounce equipment is military or experimental in nature; the Naval link between Washington and Hawaii, which employs huge 85 ft antennae is probably most publicized.

## Digital System Breadboarded without Solder



Gold-plated brass eyelets with flexible rubber cores replace soldered connections in a breadboarded digital data-processing system. Big savings in design and development time—the obvious advantage of temporary circuitry—is accompanied by substantial reduction in component cost: Banishment of the hot soldering iron means fewer \$50 transistors for the scrap pile. Developed by California Computer Products Inc., the new breadboarding technique is hailed as a happy medium between use of a schematic drawing and a printed circuit board.





SEPARATE CASTINGS, bonded together in areas indicated, form complete complex casting shown on the right.

## Cut rejects! Fabricate complex castings with

Now you can simplify production of hollow castings—and end costly rejects by casting them in sections, then bonding the sections together with high-strength SCOTCH-WELD Structural Adhesives, such as EC-1386!

By so doing, you eliminate the high rejection rate that often accompanies sand molding. You eliminate the costly machining and equipment required for mechanical fastening. You eliminate the wasteful, space-consuming bosses or flanges.

All you need is a flow gun and an oven. EC-1386 is a 100% non-volatile liquid and is solvent free. Thus, waste is negligible; no pre-drying is required before

joining the sections. The adhesive bond can be cured to high ultimate strength quickly in an air-circulating oven (one to two minutes at 500°F. bond line temperature). And the cured bond can be machined for final touch-up operations. EC-1386 also serves to fill in voids, so that parts need not be held to close tolerances.

See how EC-1386 can help you cut costs, simplify and speed production and improve product quality. And learn how other 3M Adhesives are helping the metalworking industry. Contact your 3M Field Engineer. Or write: AC&S Division, 3M Company, Dept. SBR-80, St. Paul 6, Minnesota.

"SCOTCH-WELD" and "CORO-GARD" are Reg. T.M.'s of 3M Co.

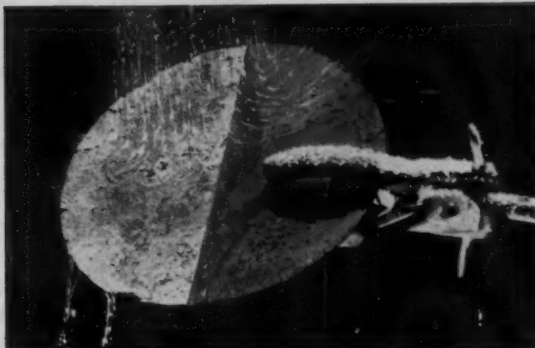


## SCOTCH-WELD®

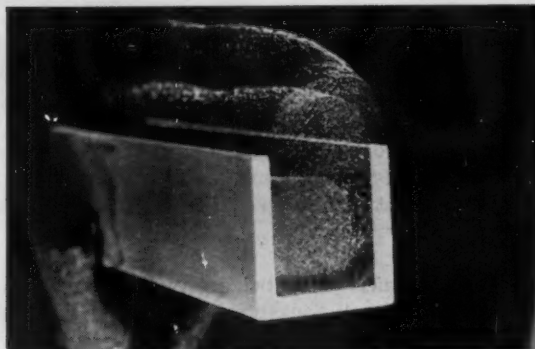
BRAND STRUCTURAL ADHESIVES

**COLD SANDWICH BONDING.** 3M Adhesive EC-1357 makes it possible for you to bond sandwich panels with a nip roller or cold press. You need no clamps or heated presses to complete tough core-to-skin bonds that resist moisture and high and low temperatures. This one adhesive bonds a variety of materials quickly, economically. Its dark color absorbs infrared heat quickly, dries fast.

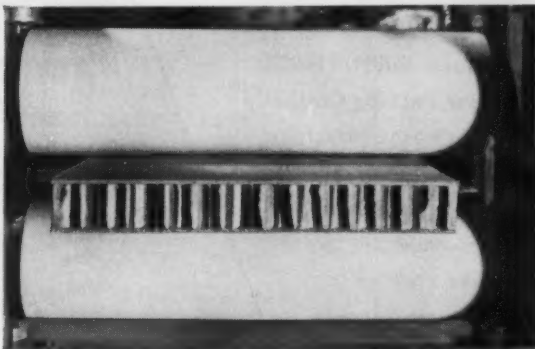
## News about other 3M products



**CORROSION RESISTANT COATING.** CORO-GARD® 1706 Brand Protective Coating resists corrosive fluids and fumes, water and abrasion. It passed these torture tests: 2000-hour corrosive salt spray attack; 20-week submersion in 20% solution of hydrochloric acid; 6-month weather exposure in Miami, Florida. For steel, aluminum, wood, concrete, cloth, even some plastics.



**SURE WAY TO SEAL.** 3M Heat Expandable Sealers expand up to 125% under the normal heat of a paint-baking cycle, cure to a tough, flexible mass that keeps out dirt, water and weather, completely seal even the most irregular gap or seam. The unexpanded solid is also efficient as a gasket replacement sealer, flange sealer and for other sealing jobs.



ADHESIVES, COATINGS AND SEALERS DIVISION

**MINNESOTA MINING AND MANUFACTURING COMPANY**

... WHERE RESEARCH IS THE KEY TO TOMORROW



# Announcing!

## A New Shaft Seal For Extremely Corrosive Service



**John Crane®**

**TYPE 20**

Made of DuPont Teflon

A new shaft seal to handle the most corrosive service conditions has been recently added to the John Crane line. Here's a seal that will stand up under all conditions of acids and salts, oxidizing agents and organic compounds.

It is so designed that all parts that normally contact the fluid are made of chemically-inert DuPont Teflon. Also, for this same reason it can be operated over wide temperature range up to 250° F.

Mechanically, its bellows type construction readily adapts it for use in all non-abrasive slurry applications. It also compensates for extreme shaft run out.

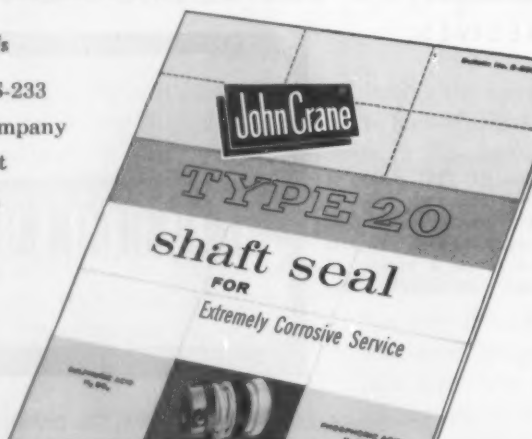
Available in single face construction for internal or external mounting, double face for internal mounting.

Full range of shaft sizes from ½" to 3".

### Get Complete Details

Request Bulletin S-233  
Crane Packing Company  
6425 Oakton Street  
Morton Grove, Ill.  
(Chicago Suburb)

In Canada:  
Crane Packing  
Company, Ltd.  
Hamilton, Ont.



### ENGINEERING NEWS



### New Slant on Strobotacs

A strobotac with style has been introduced by General Radio, West Concord, Mass. It generates brilliant white-light flashes at rates from 110 to 25,000 rpm, each lasting 1 to 6 microseconds. A specially developed lamp produces the high-intensity flashes with peaks of 0.21, 1.20 and 4.2 million candlepower. The entire assembly, packaged for convenience, is housed in a flip-tilt case that provides protection, yet flips open quickly.

### NBS Starts Building Basic Plasma Theory

Will Fill in Data Gap On Hot, Ionized Gases

WASHINGTON—There isn't enough basic data available on the behavior of hot gases and plasmas, says the National Bureau of Standards. And what does exist can't be trusted. To fill the gap, the Bureau is broadening its programs to include research on plasmas.

Scientists at NBS have learned a lot from related studies on solar phenomena, atomic properties and structures, radio-wave propagation in a plasma, etc. They feel the time has come to unify plasma theory by "cross fertilizing" other specialized fields. Disciplines to be unitized include gaseous electronics, astrophysics, atomic physics, microwave physics, and many others.

Plasmas—strongly ionized gases—are hard to characterize. Frequently they're so far from equilibrium that "temperature" has little meaning. Other quantities, such as pressure, density, and electrical con-



ductivity, are also vague when the gas departs from local thermodynamic equilibrium. The only accurate way to define a plasma is to determine a large number of its atomic properties.

In the NBS unified approach, basic properties will be determined and singled out for detailed study. Just getting under way, the program requires new tools and standards. Many of the instruments that will be needed are already well along in the design stage:

- A 35-ft spectrograph for use in the vacuum ultraviolet. The instrument will be able to carry out high-resolution spectroscopy to an accuracy never before possible.

- A "thermal light source" for measurement of energy-transition probabilities within the atom. With such a source, NBS researchers will be able to measure local temperature of a well-mixed plasma stream near equilibrium. The device will be used to study an injected trace of gas of known properties, and temperature and transition probability will be calculated from the data obtained.

- A plasma generator and related equipment designed to determine thermal conductivities of hydrogen and helium in shock waves between 10,000 and 50,000 K.

In addition to new instruments, new theoretical approaches are being developed: Automatic-computing techniques, real gas corrections, and equations of state for very dense gas at high temperature.

## Meetings and Shows

Sept. 6-16—

Production Engineering Show to be held at the Navy Pier, Chicago. Further information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 6-16—

National Machine Tool Builders Association. Machine Tool Exposition to be held at the International Amphitheatre, Chicago. Additional information is available from (Please turn to Page 48)

## EDWARDS DEVICES CAN COMMUNICATE DEPENDABILITY IN YOUR PRODUCT

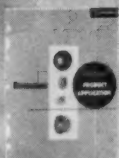


FOR FIRE WARNING SIGNAL  
EDWARDS BELL

STEWARDESS CALL SIGNAL  
EDWARDS MELOCALL® BUZZER

LANDING GEAR WARNING SIGNAL  
EDWARDS HORN

Whenever you need an electrically-activated signal, contact or indicating device, make sure it's made by Edwards... your assurance of complete dependability. The Edwards Company is the oldest and largest manufacturer of a complete line of products for control, communication and protection. Electrical distributors from coast-to-coast maintain a complete stock of all types of devices.



CATALOG S-100 OEM for designers and specification engineers gives complete details. Ask for your copy. Edwards Co., Inc., Norwalk, Conn. (In Canada: Edwards of Canada, Ltd., Owen Sound, Ontario.)

Other typical functions being performed: Foul line signal for bowling alleys/Activating buttons on pari-mutuel recorders/Annunciator indicators for motor trouble on conveyors and escalators/Oil pressure warning on diesel engine/Activating push buttons on electric scoreboards/Rear door signal for busses and trucks/Machine gun sound for toy airplane rides/Activating device for electric sprayers/Telephone buzzers/Dictating machine signal/Trouble signals on (visual or audible) control panels/Back-up signals on taxis, trucks and busses

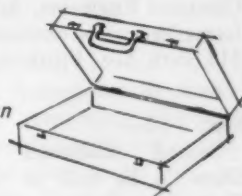




# ***A.O. Smith has the horses!***

800 to 1 hp favorites for quiet operation, low maintenance and long-life service...

*all from the case of the A. O. Smith Motor Man*



The horses of A. O. Smith make up the dandiest remuda an integral motor user ever saw. A complete line of long-lived "easy keepers" — that includes...

**SINGLE-PHASE DRIPPROOF INTEGRALS**  
(1-5 hp). Tough rolled-steel frames have mountings harnessed to either old or new NEMA standards. Exclusive sealed starting switch keeps 'em running free and easy.

**POLYPHASE DRIPPROOF INTEGRALS**  
(1-800 hp). These front-runners are sound of wind, thanks to extra-value ventilation and insulation... sound of limb, thanks to extra care in electrical and mechanical design.

And A. O. Smith delivers the horses! Our motor man near you is on his mark with 24-hour action on all parts and service orders. He'll also show you a complete line of fractional-hp motors.

COPYRIGHT 1960, A. O. SMITH CORP.



(Continued from Page 45)

Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

**Sept. 7-9—**

**Joint Automatic Control Conference** to be held at Massachusetts Institute of Technology, Cambridge, Mass. Sponsors are Instrument Society of America, American Society of Mechanical Engineers, American Institute of Electrical Engineers, Institute of Radio Engineers, and American Institute of Chemical Engineers. Additional information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

**Sept. 7-15—**

**Second Coliseum Machinery Show** to be held in the Chicago Coliseum. Further information is available from A. Byron Perkins & Associates, 2216 S. Hill St., Los Angeles 7, Calif.

**Sept. 12-13—**

**Material Handling Institute Inc.** Fall Meeting to be held at the

Cavalier Club, Virginia Beach, Va. Further information is available from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

**Sept. 12-15—**

**Society of Automotive Engineers Inc.** National Farm, Construction, and Industrial Machinery Meeting, including production forum and engineering display, to be held at the Milwaukee Auditorium, Milwaukee. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

**Sept. 15-16—**

**American Society of Mechanical Engineers.** Engineering Management Conference to be held at the Morrison Hotel, Chicago. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

**Sept. 18-21—**

**American Society of Mechanical Engineers.** Petroleum - Mechanical Engineering Conference to be held at the Jung Hotel, New Orleans, La. Further information is available

from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

**Sept. 19-20—**

**Steel Founders' Society of America.** Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

**Sept. 21-23—**

**American Society of Mechanical Engineers - American Institute of Electrical Engineers Power Conference** to be held at the Bellevue-Stratford Hotel, Philadelphia. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

**Sept. 26-29—**

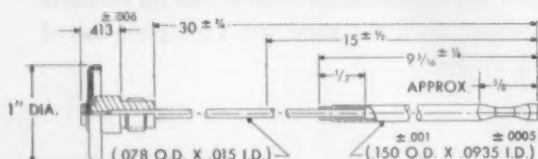
**American Welding Society.** Fall Meeting to be held at the Penn-Sheraton Hotel, Pittsburgh. Additional information is available from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

**Sept. 26-30—**

**Instrument Society of America.**

TEMPERATURE SENSOR

# ACCURATE, NO-DRIFT CONTROL FOR APPLIANCES SOLVED BY ROBERTSHAW DIASTAT® ASSEMBLY

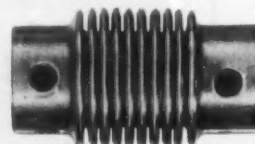
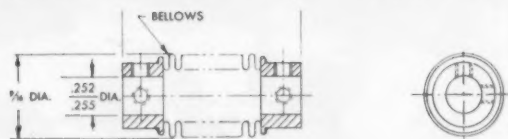


Temperature sensing elements like this one for a range oven control offer permanent accuracy with no drift, consistent calibration, no resetting, long life and savings in space, weight and unit cost. Ambient temperature sensing devices are unnecessary in most applications. Typical stroke is .035" for a 1" diameter stainless steel diaphragm. Ideal for sensing temperatures up to 650°F. All units are custom engineered and delivered as pre-assembled "packages," tested and ready for mounting. **WRITE FOR BULLETIN N-608**

Circle 423 on Page 19

FLEXIBLE COUPLING

# ELIMINATE BACKLASH, END-PLAY! ABSORB VIBRATION, SHOCK WITH ROBERTSHAW FLEXIBLE COUPLINGS



Servomechanisms, instruments and similar drive and control systems are the big users of these small, flexible units. Ideal for guarding against misalignment friction and bearing wear problems. Save space and weight. Cut down noise. Simplified design utilizes seamless metallic bellows, in choice of several metals, connected to two hubs. Sizes from 1/4" O.D. Stock sizes accommodate shafts from 1/8" to 1/2". Other sizes custom-engineered. **WRITE FOR DATA SHEET N-808**

Circle 424 on Page 19

**Instrument-Automation Conference and Exhibit and 15th Annual Meeting** to be held in the Coliseum, New York. Additional information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

**Sept. 27-30—**

**American Rocket Society Inc. Space Power Systems Conference** to be held at the Miramar Hotel, Santa Monica, Calif. Additional information can be obtained from society headquarters, 500 Fifth Ave., New York 36, N. Y.

**Sept. 27-30—**

**Association of Iron and Steel Engineers. Exposition and Convention** to be held at the Auditorium, Cleveland. Further information is available from AISE headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

**Oct. 9-12—**

**American Society of Mechanical Engineers. Rubber and Plastics Conference** to be held at the Lawrence Hotel, Erie, Pa. Further information can be obtained from Meetings Dept. ASME, 29 W. 39th St., New York 18, N. Y.

**Oct. 9-14—**

**American Institute of Electrical Engineers. Fall General Meeting** to be held at the Morrison Hotel, Chicago. Additional information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

**Oct. 10-11—**

**Sixth Conference on Mechanisms** to be held at Purdue University, Lafayette, Ind. Conference is sponsored by Purdue and MACHINE DESIGN. Further information is available from Editor, MACHINE



**DESIGN, Penton Bldg., Cleveland 13, Ohio.**

**Oct. 10-12—**

**National Electronics Conference** to be held at the Hotel Sherman, Chicago. Sponsors include American Institute of Electrical Engineers, Institute of Radio Engineers, Illinois Institute of Technology, Northwestern University, and University of Illinois. Further information can be obtained from NEC headquarters, 228 N. La Salle St., Chicago 1, Ill.

**Oct. 10-14—**

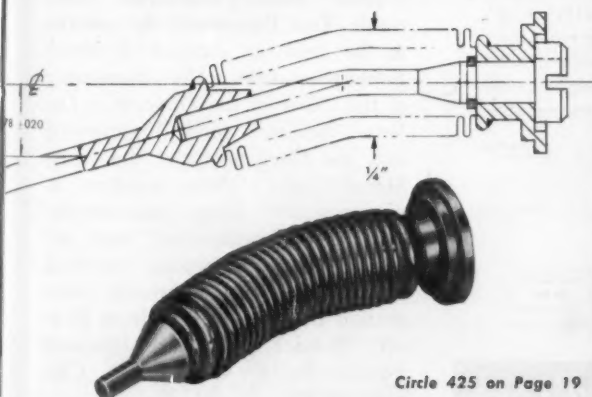
**Society of Automotive Engineers Inc. National Aeronautic Meeting**, including manufacturing forum and engineering display, to be held at the Ambassador Hotel, Los Angeles. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

**Oct. 12-14—**

**American Vacuum Society. Seventh National Symposium** to be

# MINIATURE BELLOWS

**SAVE SPACE AND WEIGHT WITH RUGGED, MINIATURE ROBERTSHAW FORMFLEX\* BELLOWS**



Circle 425 on Page 19

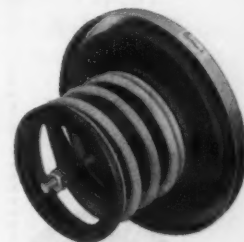
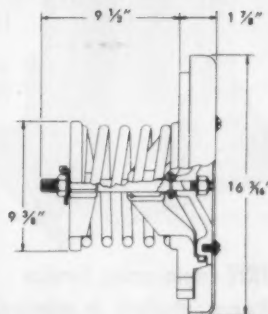
Now... hydraulically formed seamless metallic bellows as small as  $\frac{1}{8}$ " O.D.! These miniature Formflex units, along with  $\frac{1}{4}$ " and  $\frac{3}{8}$ " O.D. sizes, permit further miniaturization in aircraft, missiles, instruments and other equipment. All sizes are available in a wide range of metals to provide the desired strength and performance characteristics. Ideal in assemblies that react to or compensate for pressure and temperature changes. Custom-engineered in any quantity you may require.

WRITE FOR BULLETIN N-100

\*Registration pending

# PRESSURE RELIEF VALVE

**VENTS PRESSURE BUILD-UP IN TRANSFORMERS, TANKS... RESEALS AUTOMATICALLY WITH NO RESETTING!**



Now you can forget breakaway seals that have to be replaced each time dangerous high pressure build-ups are relieved. Robertshaw Pressure Relief Valve operates instantaneously. No moisture or contaminants can enter vessel during blow-off or automatic resealing and resetting. No periodic inspections necessary.

WRITE FOR ENGINEERING DATA SHEET N-908

**Robertshaw**

**BRIDGEPORT**  
THERMOSTAT DIVISION  
ROBERTSHAW-FULTON CONTROLS CO.  
Milford, Conn.

Circle 426 on Page 19





**BOOST**  
Production  
•  
**STOP**  
Down-Time  
Losses  
with



**CYLINDERS**

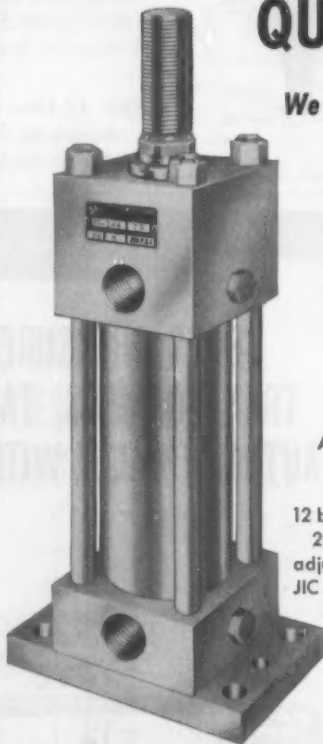
Last Longer

Compact,  
Fit Anywhere

**PROMPT**  
Off-the-shelf  
**DELIVERY**  
Reduces your  
inventory,  
saves money



## YOU can prove our QUALITY!



*We invite you to test  
our air  
and hydraulic  
cylinders against  
any other!  
Our confidence  
is in our  
quality.*

**S-P COMPLETE LINE:**  
Air: 200 psi; Hydraulic:  
2000 psi (operating),  
3000 psi (non-shock);  
12 bore sizes—1/2" to 14";  
23 mounting types; fully  
adjustable cushions; 100%  
JIC and automotive stand-  
ards; interchangeable.

A.A. 0000

**FREE Engineering Service**  
**Representatives in principal cities**  
**Phone or Write Today**



**THE S-P MANUFACTURING CORP.**  
30201 Aurora Rd. • Solon, Ohio

A BASSETT COMPANY • IN GREATER CLEVELAND • ESTABLISHED 1916

Non-Rotating and Rotating AIR and HYDRAULIC CYLINDERS • VALVES  
POWER CHUCKS • COLLET and DRILL PRESS CHUCKS • ACCESSORIES

### ENGINEERING NEWS

held at the Cleveland-Sheraton Hotel, Cleveland. Further information is available from society headquarters, P. O. Box 1282, Boston 9, Mass.

**Oct. 12-14—**

**Gray Iron Founders' Society.** 32nd Annual Meeting to be held at the Netherland Hilton Hotel, Cincinnati. Further information is available from society headquarters, National City-E. Sixth Bldg., Cleveland 13, Ohio.

**Oct. 14-15—**

**American Society for Quality Control.** 15th Midwest Conference to be held at the Broadview Hotel, Wichita, Kans. Further information can be obtained from the program and publicity vice-chairman, Howard K. Mitchell, 602 S. Brookside, Wichita 18, Kans.

### Short Courses and Symposia

**Sept. 12-16—**

**Course on Technical Report Writing for Engineers and Scientists** to be held at the University of California, Los Angeles. Additional information is available from Engineering Extension, Room 6266, Engineering Bldg., Unit II, University of California, Los Angeles 24, Calif.

**Sept. 14-15—**

**Joint Military-Industrial Electronic Test Equipment Symposium** to be held at Armour Research Foundation under the sponsorship of the Office of the Director of Defense Research and Engineering and the Department of the Army Signal Corps. New concepts in measurement, latest instrumentation design techniques, and advanced data processing methods will be covered. Additional information can be obtained from Robert Brausch, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

**Sept. 19-30—**

**Technical Report Writing for Engineers and Scientists Seminar** to be held at Pennsylvania State Uni-

versity. Lecture, discussion, and workshop sessions will cover all phases of technical report preparation. Further information is available from Conference Center, The Pennsylvania State University, University Park, Pa.

#### Oct. 4-7—

**Eighth Annual Human Engineering Institute** to be conducted by Dunlap & Associates, Stamford, Conn. Program will include three days of technical sessions, a half-day on management and contractual aspects of human engineering efforts, and opportunity for private conferences. Further information can be obtained from Dunlap & Associates, 429 Atlantic St., Stamford, Conn.

#### Oct. 14-15—

**Revolution in High-Speed Processing Symposium** to be held by the Society of Photographic Scientists & Engineers in Washington, D. C. Short access time, compact, simplified photographic processing equipment will be discussed. Further information can be obtained from SPSE, Box 1609, Main Post Office, Washington, D. C.

#### Oct. 20-21—

**National Symposium on Hypervelocity Techniques**, sponsored by the Institute of the Aeronautical Sciences, to be held at the Shirley-Savoy Hotel, Denver. Additional information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.



"It says 'Patent Refused'."



## RADIATION CONTROL

*AccuRay*® instrumentation is based on the radiation of gamma rays from a source unit containing radium-226 or cesium-137. Source units are effectively shielded by housings cast in Meehanite by Hamilton Foundry. The density, and soundness of Meehanite castings provide the positive protection essential for safe and reliable instrumentation.

When buying castings, the skill and integrity of Hamilton Foundry is your best insurance that specifications—and delivery schedules—will be met.

\**AccuRay* is the registered trade mark of Industrial Nucleonics Corporation

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (MODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD



# HAMILTON FOUNDRY INC.

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What do you need in an  
adjustable speed drive?

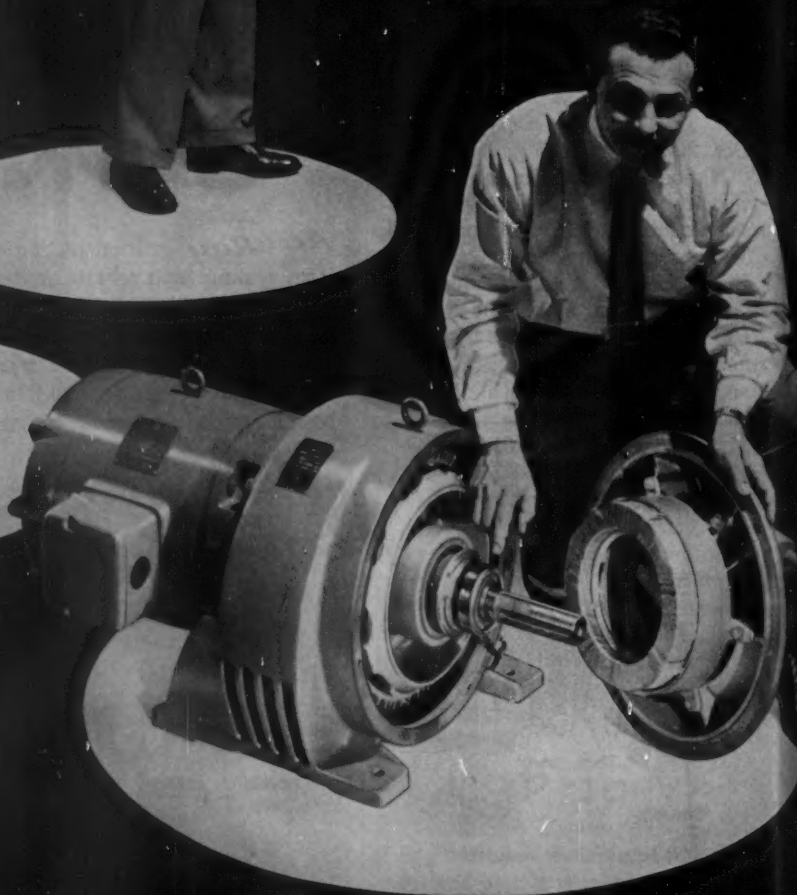
*Better Regulation!*



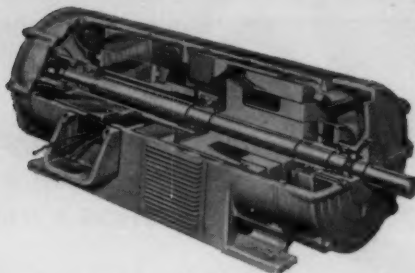
*Compactness!*



*Less Maintenance!*



7½-hp Ajusto-Spede Drive



Common motor-drive housing for units up to 7½ hp saves space — can be foot or flange mounted. Larger sizes up to 100 hp with individual motor and drive housings mounted integrally.

*NEW design news from Louis Allis*

## **...The Louis Allis AJUSTO-SPEDE® drive Is more compact, precise, and trouble-free**

Here's an adjustable speed drive that allows *truly precise* machine operation. Speed regulation is automatic and stepless — results in faster, more efficient production at lower cost, with less waste, and minimum wear on equipment.

These and other benefits are yours when you use the improved Louis Allis Ajusto-Spede drive. For example, it can be set before or during operation to deliver any desired speed within its range. Its *exclusive* tachometer feedback circuit monitors the output speed and *automatically corrects speed and holds it* regardless of load changes.

This improved drive requires minimum maintenance. Its stationary field has no brushes, commutators, or slip rings to cause trouble. The source of power is an equally trouble-free standard a-c squirrel cage motor. The cast-iron housing keeps out dirt, chips, and moisture — resists corrosion.

The compact Ajusto-Spede also saves space. Integrally-mounted motor and drive simplify handling — can be easily adapted for installation on new or existing machines. Controls can be mounted at the machine or any other convenient position.

The Louis Allis Ajusto-Spede drive is the practical solution to almost every application that requires dependable, easily controlled adjustable speed. It is the answer to precise operating speeds for machine tools, process machinery, test equipment, windups, conveyors, printing presses, and other equipment. Contact your Louis Allis District Office for information and application help. Or write for bulletins 2750 and 2800 — The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

© Ajusto-Spede is a registered trademark of the Eaton Mfg. Co.



MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

# **LOUIS ALLIS**





Closeup of coated aluminum "clapboard" sheathing joint designed to permit expansion and contraction of house siding. Plastic-based coating stays intact around intricate bends.

## **OUTDOORS—A DURABLE VINYL-BASED PAINT TO PRE-COAT HOUSE SIDING BEFORE FORMING**

Baked onto the metal before forming, vinyl-based coatings stand up under the strain of shaping and years of service as well. On house siding, weather resistance is a big factor, and the adjoining photograph shows how the aluminum clapboard on a Milwaukee home looked after nine years without refinishing. The coating is still intact.

Shakes as well as clapboards are being formed from this pre-coated metal. On both types, the vinyl-based finish holds fast, with no cracking, chipping, or peeling during shaping, assembly and service. Both primer and topcoat can be applied by roller, brush, or spray. Baking turns the topcoat into a tough, flexible, weather-resistant finish that looks good as new for years with only an occasional washing.

One company pre-coats and bakes the finish on aluminum sheathing which is then formed over an insulation board made of wood fibers, asphalt-treated for weather and water resistance. Another manufacturer designed a special interlocking joint (closeup) that permits expansion and contraction with temperature changes to prevent buckling. What vinyl-based coatings are doing for building materials, they will do for many other products that can be made from pre-coated metal sheets formed at a saving.

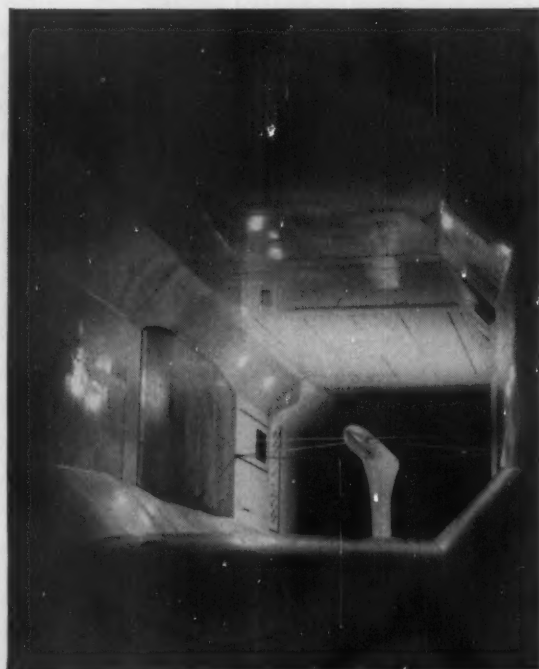
# LET PLASTIC-BASED COATINGS

## **ARTIFICIAL WINDSTORM—OTHER COATINGS BLEW AWAY, BUT PHENOLICS STUCK TO THIS WIND TUNNEL**

Before phenolic-based coatings were tried, the paint inside this 8-foot transonic wind tunnel would literally blow off the surface. Nuts and bolts occasionally loosened from models struck the sides and scored the paint. Ordinary paints didn't last long under these conditions.

But a coating based on BAKELITE Brand phenolics was still adhering firmly, in good shape, after two years. Along with extreme durability, its smooth glossy surface demonstrated far greater freedom from friction and resistance to scoring.

Plastics have brought a new set of performance standards to the coatings field. They fit into the new service-environments your designs have to meet, and deserve thorough investigation when you're planning a new approach.



## INDOORS—A TOUGH, HARD-WORKING FINISH THAT DRESSES UP ADMIRAL'S PORTABLE TV

Many portable TV cabinets are metal, but Admiral's has a big plus—a simulated morocco leather finish baked on before forming. It's based on BAKELITE Brand vinyl dispersion resins, .012 in. thick, applied to the flat .032 in. steel sheet. Inside, there's another coating of clear vinyl to prevent rust.

The steel sheets are handled and stacked without special treatment, yet the finish is unharmed. They are shaped on the same presses and dies used for unfinished metal, at 250 tons pressure. And even 180 deg. bends do not harm the coating.

The savings with pre-coating have enabled Admiral to offer this de-luxe morocco-leather effect at their standard retail price. Keep vinyls in mind when sturdy housings and other products have to be formed and finished with speed and economy.

◀ Closeup shows louvers cut and formed into steel sheet pre-coated with dispersion coating based on BAKELITE Brand vinyl resin. Notice that the coating is undamaged, preserving its grainy morocco leather effect.

# HELP YOUR DESIGNS IN METAL

**Some of your unusual ideas may work best in metal with plastic-based coatings applied before or after forming. Here are three typical examples:**

PLASTIC-BASED COATINGS have helped metals meet new requirements. With their special and unusual properties, plastics have helped bring more freedom to designers, increased product attractiveness, improved performance, and reduced costs. This is true in a variety of product fields beside coatings—molded, laminated, and extruded plastics also provide a host of new directions for your ideas to take. Learn about BAKELITE Brand polyethylenes, epoxies, phenolics, styrenes, and vinyls and their use in design. Their properties are listed in Sweet's Product Design File, section  $\frac{2a}{ui}$

For specific information on how plastics can help with your design problems, mail the coupon today.

"Bakelite" and "Union Carbide" are registered trade marks of Union Carbide Corporation.

## UNION CARBIDE

Dept. CX-84, Union Carbide Plastics Co.  
Division of Union Carbide Corporation  
270 Park Avenue, New York 17, N. Y.

Please send me information on coatings for metals.  
Please send me general information on BAKELITE  
Brand plastics for design.  
The type of application being considered is \_\_\_\_\_

NAME \_\_\_\_\_

FIRM NAME \_\_\_\_\_

STREET \_\_\_\_\_

CITY \_\_\_\_\_ ZONE \_\_\_\_\_ STATE \_\_\_\_\_



# NO SCORING

...after 25,000,000 cycles!

**Alkon series D cylinders have exclusive nylon\* piston bearings to prevent scoring, prolong cylinder wall and piston rod life.** The secret is silky smooth nylon moving along a chrome-plated steel cylinder barrel and stainless steel piston rod, both roller burnished to a 4 micro-inch finish. No chance for scoring. Just slick, trouble-free operation, day after day, for 25,000,000 cycles and more! More facts: the Alkon Series D cylinder is built for 250 psi air service. Available in all mounting styles... **3-way flush mountings at no extra cost.** Exceed toughest J.I.C. standards. All are ready for immediate delivery with or without cushions. **The Alkon series D cylinder costs at least 25-40% less than any other comparable cylinder!**

Alkon also manufactures compatible 4-way valves and pneumatic drill units.

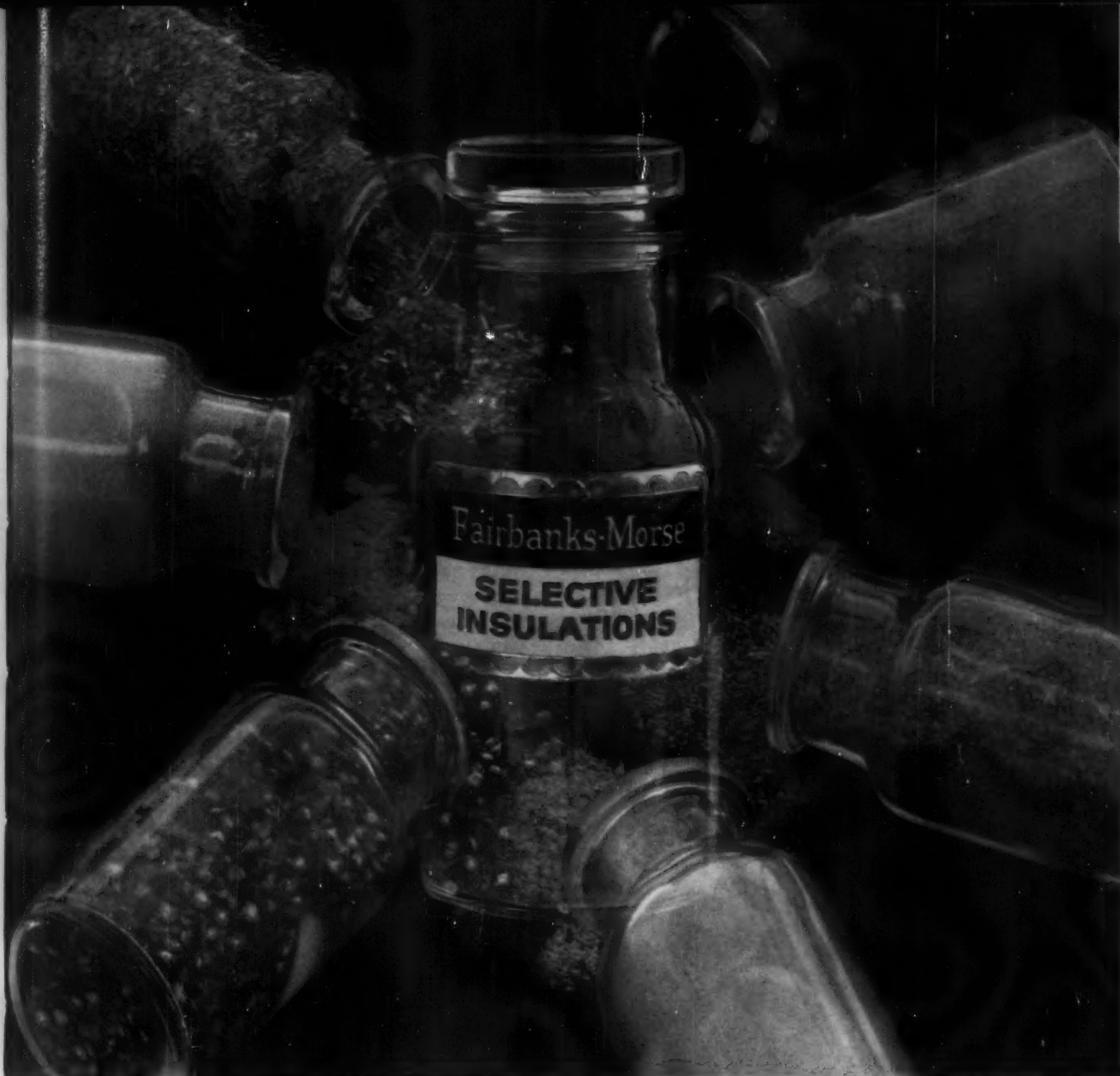


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## The magic of our ingredients makes electric motors better...

Just as a good chef wouldn't use only one all-purpose spice to make a specialty... we don't make an electric motor with one all-purpose insulation.

We build motors with **SELECTIVE INSULATIONS**...

**SELECTIVE INSULATIONS** are the magic ingredients that make the difference between merely good motors—and the famous dependability, low maintenance, uninterrupted productivity, and prolonged service of Fairbanks-Morse electric motors.

We actually "tailor" a wide range of insulating materials and processes

to motor applications, according to specific operating conditions. We never standardize to the average.

**SELECTIVE INSULATIONS** meet emergency overloads, temperature extremes, corrosive atmospheres.

We select, test, treat, and prepare insulating materials for the motor... and the job.

We build electric motors that are insulated, rated, and dimensioned to furnish unfailing power—for any purpose.

The magic of our ingredients makes a Fairbanks-Morse electric motor better... and a better buy.



### WHAT DO YOU NEED IN A MOTOR?

1 h.p. to 10,000 h.p. ... open or weather-protected ... vertical or horizontal ... synchronous or induction ... AC or DC ... we'll build it—and build it to last! Write: Fairbanks, Morse & Co., Freeport, Illinois, for full information.

## Fairbanks, Morse

ELECTRICAL DIVISION

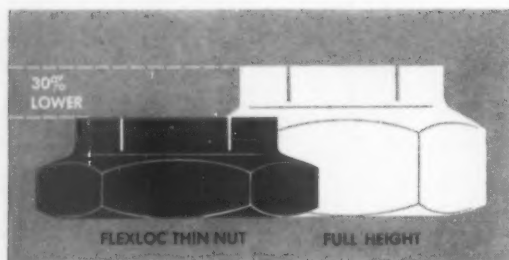
A MAJOR INDUSTRIAL COMPONENT OF  
**FAIRBANKS WHITNEY CORPORATION**





## SMALL WONDER: **FLEXLOC** THIN NUT

**30% lower and lighter, yet still stays put for keeps!**



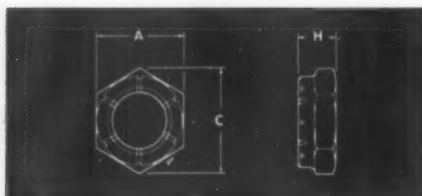
Frequently you need a smaller, lighter locknut, yet you can't afford to sacrifice one whit of holding power. That's where self-locking FLEXLOC thin nuts come in.

Since they are 30% lower than full height locknuts of the same diameter, FLEXLOC thin nuts allow you to design more compact bolted joints. They often fit into space where clearance is insufficient for standard height nuts. Also, thanks to minimum projection, they improve appearance and increase safety.

And FLEXLOC thin nuts save precious weight—they themselves are 30% lighter and you save additional weight by using shorter bolts or studs.

What about reliability? FLEXLOC thin nuts won't budge, even in the face of impact or vibration. This is because every thread, including those in the locking section, carries its full share of the tensile load.

FLEXLOC thin nuts also . . .



- Simplify design—1-piece fasteners (no auxiliary locking elements required)
- Save production time—fewer turns needed to seat
- Lock without seating—serve as stopnuts as well as locknuts
- Can be readily removed and repeatedly reused
- Available in stainless as well as alloy steel

FLEXLOC thin nuts come in sizes from #6 to 1½ in. For complete information, see your authorized SPS distributor or write Standard Pressed Steel Co.—manufacturers of precision threaded fasteners and allied products in many metals, including titanium—for Bulletin 2339. INDUSTRIAL FASTENER Division, SPS, JENKINTOWN 18, PENNSYLVANIA.

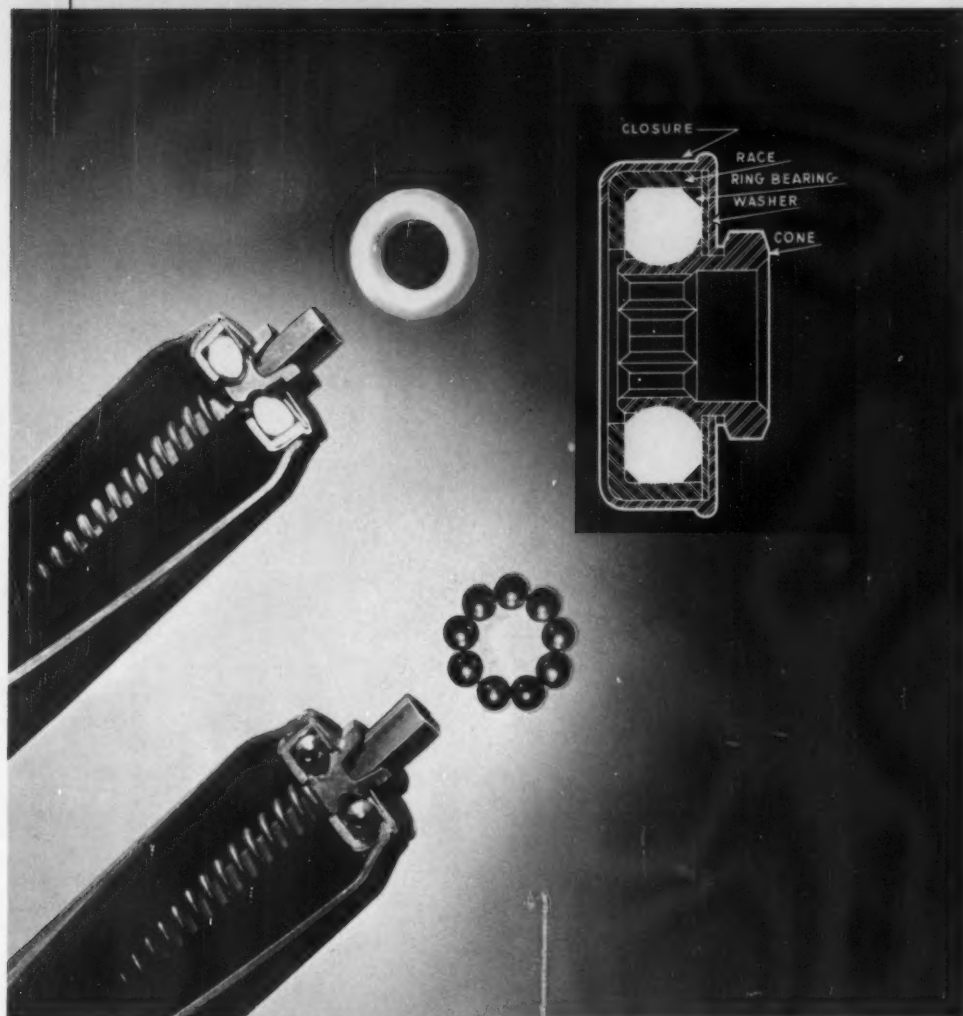
**SPS**

*where reliability replaces probability*

working with

**Du Pont Delrin®**

one of Du Pont's versatile  
engineering materials



Ring bearings molded by Sinko Tool and Manufacturing Co., Chicago.

**Ring bearing  
illustrates  
why Delrin®**

**is doing so many jobs once reserved for metals**

The use of roller and wheel conveyors in manufacturing, wholesale and retail business has become commonplace today. But as universal as their use is, they have remained relatively noisy mechanisms.

This objection prompted the Rapids-Standard Co., Inc., Grand Rapids, Mich., to seek a new material to replace the steel balls in the bearings of their conveyors. Their choice was rings of "Delrin" acetal resin (roller conveyor shown above). With "Delrin", the conveyors are now "virtually noiseless". The bearings require no lubrication in service, and they will not corrode in normal use. In addition, weight

savings of 50-65% have been realized.

This ability of "Delrin" to compete with steel, die-cast zinc and aluminum, cast and machined brass, and cast iron (see reverse side for additional examples) stems from its unique combination of physical properties and design-production economies. With "Delrin", manufacturers are discovering new ways to improve product performance—often at lower cost.

• • •

We will welcome the opportunity to assist you in evaluating how "Delrin" can bring these advantages to your products. A coupon appears on the reverse side for your convenience.

**DU PONT**

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING  
... THROUGH CHEMISTRY

working with

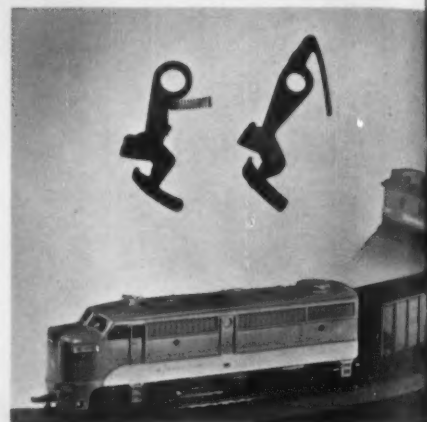
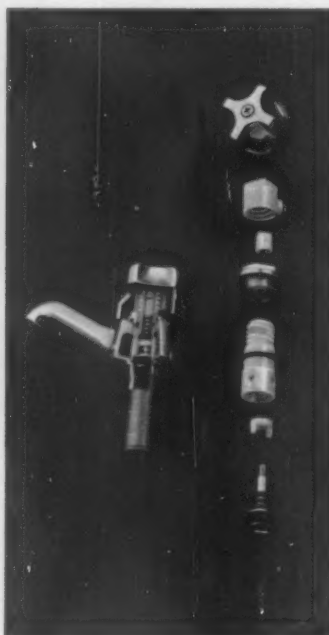
**Du Pont Delrin®**

one of Du Pont's versatile  
engineering materials

**These typical end-uses reveal  
performance and cost advantages  
of Delrin®**



The head frame (top) of the new "Lady Ronson" Superbe electric shaver is molded of "Delrin", saving 80% of the weight of the previous gold-plated die-cast zinc part. Ronson Electric Shaver Corp., Stamford, Conn., specified "Delrin" because it could be molded to and hold the necessary dimensions, have a smooth luster without finishing and resist body oils and colognes.



The Lionel Corporation, Irvington, N. J., recently introduced a new HO train line featuring a one-piece coupler molded of "Delrin". Because "Delrin" has the resilience to provide the desired springing action, Lionel designed the integral unit to replace a two-part assembly of coupler and coil spring. The result: a significant assembly saving plus a new sales feature. "Delrin" is also used for the axles, journals and two other truck parts. (Molded by Lionel and Gries Reproducer Corp., New Rochelle, New York.)

Four parts (in white) of this self-seating faucet are molded of "Delrin", saving 80% of the cost of the machined brass components formerly used by the Kel-Win Manufacturing Co., Inc., Richmond, Va. Kel-Win chose "Delrin" because it resists corrosion and mineral buildup, remains dimensionally stable and eliminates machining operations and rejects. (Molded by Dominion Plastics Co., Colonial Heights, Virginia.)

"Delrin" acetal resin offers designers such properties as strength, stiffness, dimensional stability, resilience and abrasion resistance; and it retains these properties even under exposure to wide variations in temperature, humidity, solvents and stress. Already hundreds of designs taking advantage of these properties, and of the cost savings made possible by rapid injection molding, have been specified or put into commercial production. We suggest that you investigate how "Delrin" can be profitably used in the products you make and the products you use. Commercial processors and our own staff of technologists are ready to assist you.

POLYCHEMICALS DEPARTMENT



BETTER THINGS FOR BETTER LIVING  
... THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)  
Department 13 Room 2507-D  
Nemours Building, Wilmington 98, Delaware

I am interested in evaluating "Delrin" for the following use:

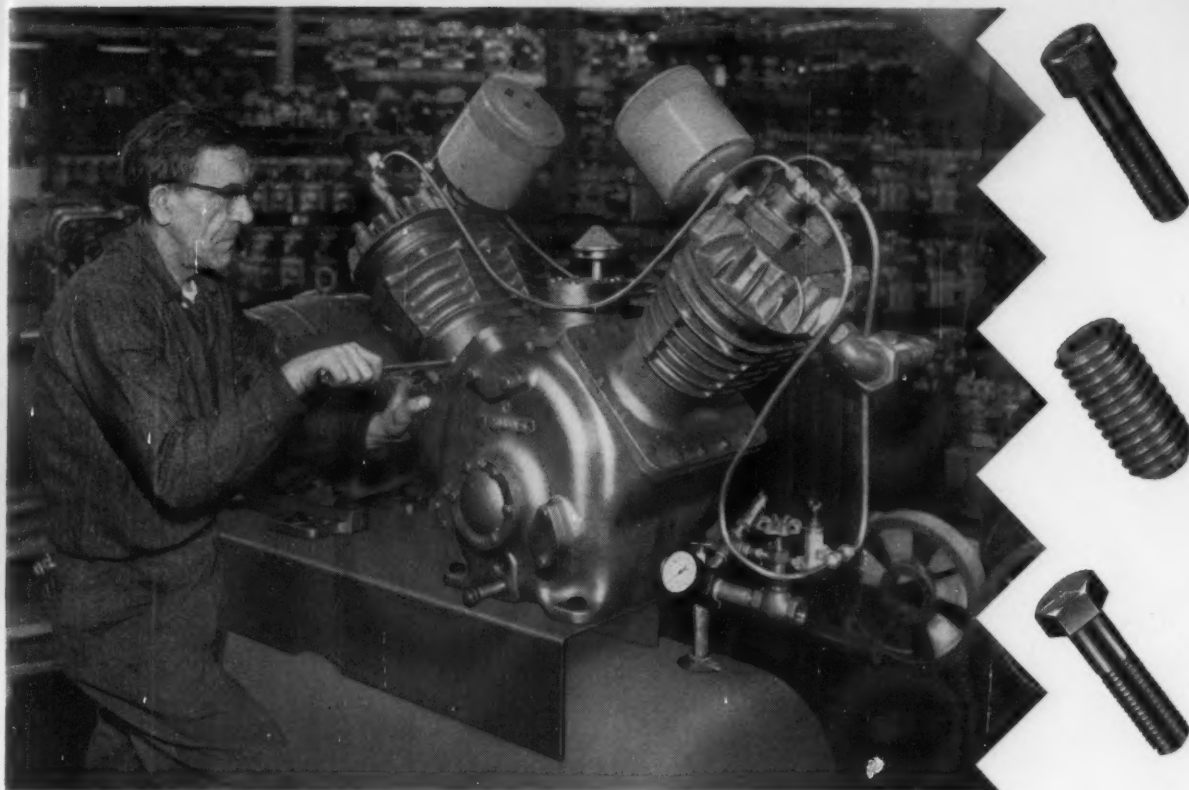
Name \_\_\_\_\_  
Company \_\_\_\_\_ Position \_\_\_\_\_  
Street \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_

**DELTRIN®** acetal resin

one of Du Pont's versatile engineering materials

Alathon® · Zytel® · Lucite®

IT PAYS TO STANDARDIZE ON STANSCREW



## Stanscrew provides faster service, adds safety for **BRUNNER** compressors

The fasteners this man is tightening must be really dependable. Dunham-Bush, therefore, maximizes the safety margin for its Brunner line by standardizing on Stanscrew heat-treated cap screws for all critical applications.

With tremendous production demands on its Hartford plant due to industry's preference for Brunner compressors, Dunham-Bush also demands a supplier who provides quick assistance on all occasions, and moves especially fast in emergencies. Stanscrew meets these requirements because complete stocks are maintained at three conveniently located plants . . . plus a management philosophy which looks on shipments within 24 hours as normal procedure,

subject to drastic improvement in emergencies.

Fast delivery and reliable products are but two of many reasons more and more industrial leaders are switching to Stanscrew. A complete selection of over 5,000 different standard fasteners . . . experienced fastener specialists to provide qualified technical assistance . . . these and many other factors underline the advantages of specifying Stanscrew for your fastener requirements.

*Why not call your Stanscrew distributor today. He will gladly arrange a prompt visit from the Stanscrew specialist who can often save you money . . . for example, by substituting a standard fastener for a costly special.*



### STANSCREW FASTENERS

**CHICAGO** | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS  
**HMS** | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT  
**WESTERN** | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

**STANDARD SCREW COMPANY** 2701 Washington Boulevard, Bellwood, Illinois





How General Electric's **TRI 55 CLAD** motor gives you MORE THAN A MOTOR...

# TRIPLE-PROTECTED **TRI 55 CLAD** MOTORS ARE BUILT TO TAKE IT!

General Electric Tri/Clad '55' motors are built to take it! Whatever your application requirements may be (long or short duty cycles . . . under ideal or adverse conditions . . . high or low temperatures) there's a Tri/Clad '55' motor to meet them.

The name "Tri/Clad" itself means "triple-protected" against electrical failure, mechanical failure and physical damage.

**ELECTRICAL PROTECTION**—Mylar\* insulation—Formex\*\* wire insulation system throughout protects against electrical breakdown caused by effects of water, heat, or stresses.

**MECHANICAL PROTECTION**—Regreaseable ball bearings, long-lasting synthesized grease, and an oversize grease reservoir contribute to long bearing life, low maintenance.

**PHYSICAL PROTECTION**—Rugged cast-iron stator frame and endshields offer protection against corrosion, rust, or physical shock.

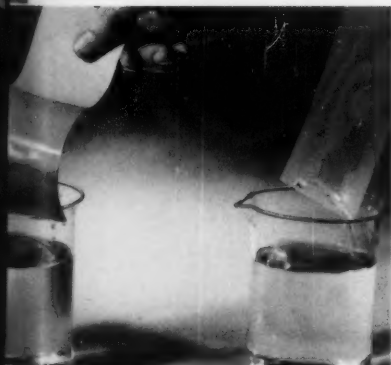
This extra ruggedness and durability found in General Electric Tri/Clad '55' motors—the ability to "take it"—pays off. It's your assurance that you're getting the best integral-hp motor that money can buy, a motor that will perform smoothly for years. It's General Electric's way of making your purchase truly *more* than a motor. Why not contact your local G-E Apparatus Sales Office? Or write Section 840-30, General Electric Co., Schenectady, New York.

Other "More Than A Motor" Benefits of G-E Tri/Clad '55' Motors: On-time Delivery • Expert Application Aid • Fast, Local Backup Service • Constant Design Innovation • Complete Line.

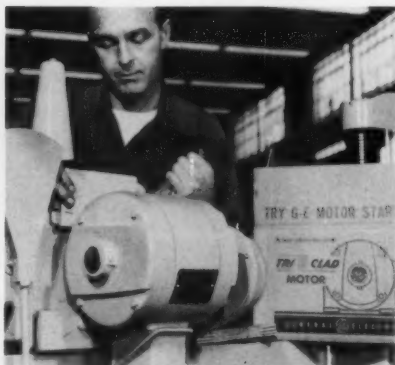
\*Trademark of DuPont Co.

\*\*Registered Trademark of General Electric Co.

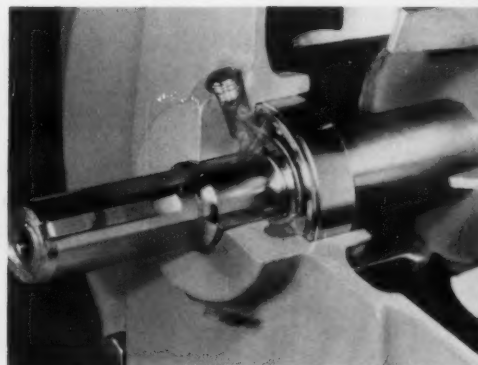
# GENERAL ELECTRIC



**MYLAR** slot and phase insulation assures long motor life, minimum maintenance. G-E motor insulation materials are non-hygroscopic.



**CAST-IRON FRAME** and endshields provide rigidity; prevent motor from being twisted out of line. Integrally-cast ribbing along bottom adds extra strength to the motor.



**LONG-LIFE BEARING SYSTEM** seals grease in, dirt out. Long-lasting grease in large reservoir increases bearing life, lengthens interval between regreasing.

**NEW  
HAMPSHIRE** } **BALL BEARINGS, INC.**  
**PETERBOROUGH, N. H.**

From the office of  
ARTHUR N. DANIELS,  
President

RE: Instrument Ball Bearings

Gentlemen:

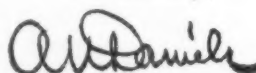
Most of us didn't learn much about anti-friction bearings in Engineering School. In my own case, we learned the difference between ball, roller and needle bearings, and that's about all. Literature on the subject is sparse; the variety of types, sizes and extra features is vast. All have their limitations, advantages and disadvantages.

This is a plea, then, for taking a Bearing Engineer into consultation before your layouts or designs are frozen. He is a professional and his services are free. We have ten of them, at your disposal, in addition to a staff of specialists at our home office.

True, they have an axe to grind: to sell you instrument ball bearings. But none of them wants to make recommendations that will fail to meet requirements, or to propose a marginal solution. Ethics of course prohibit their revealing your plans to others. Sometimes they will say "No," or "Maybe," or "Tests must be run." We've not accumulated all the answers yet, doubtless never will. Then, for confirmation, a competitor can be called in. We have a few who know a little about it. And, as sometimes happens among professionals, he may dissent, leaving the judgment up to you.

We believe too that our own new 150-page Design Manual is the most comprehensive treatise on instrument ball bearings published. We shall be glad to send you a registered copy by return mail.

Sincerely,



A. N. Daniels  
President

the

neg'ator®

sketchbook

The NEG'ATOR® Spring is a new basic mechanical component—a coiled band spring which extends many times its original size without the increasing force common to conventional springs. Used as an extension spring, a motor, band, clamp, or clip, this revolutionary new constant-force component upsets all previous spring principles by doing what springs have never done before.

## NEG'ATOR® SPRINGS INCREASE BRUSH LIFE IN AIRPLANE PROPELLER DE-ICER

Motor and generator manufacturers who have used NEG'ATOR brush springs have benefited in two ways, namely: (1) in the cost of replacements; and (2) in the labor involved in changing brushes.

An interesting picture of the manner in which brush material is worn away in the course of machine operation is provided by the curve, Fig. 2.

An example of how NEG'ATOR brush springs have been applied to increase brush life is shown in Fig. 3. This drawing shows the brush spring system used in the de-icing unit of Hamilton Standard's 54H50 Hydramatic propellers on the Lockheed Electra Turbo-prop Transport.

The brush assembly, which provides electrical continuity from the power source to the afterbody heaters and through the slip ring to the spinner and blade heaters, uses 12 NEG'ATOR springs and electrical contacts. Each spring is made of spring-tempered stainless steel .0048 in. thick, .25 in. wide, with a coil diameter of .39 inches. Each spring exerts a constant pressure of 1.5 lbs. on its brush assembly. Allowable brush wear length is .33 inches.

The NEG'ATOR spring exerts optimum pressure on the brush at all times. In other de-icing units with conventional compression springs a higher brush pressure had to be used because of the spring gradient. This accelerated brush wear.

In addition to increasing brush life, the NEG'ATOR springs saved space. For the same size brush, the space required by the constant-pressure spring is about 1/3 that of the conventional brush spring.

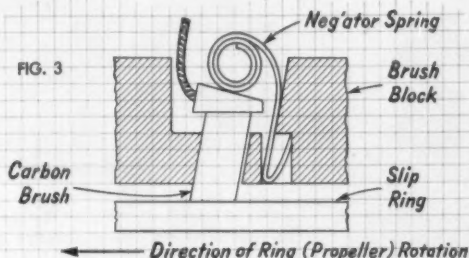


FIG. 3. Brush spring system used in de-icer. Note the simplicity with which the NEG'ATOR constant-pressure spring is mounted in the brush block. The spring is inserted by forcing its end, which has been bent to form a tang, through the brush block slot. Once inserted, the tang expands slightly within a recess cut in the block to secure the spring. The spring coil bears against the top of the brush. As the brush wears, the spring coils itself in an attempt to return to its natural state, maintaining an unvarying contact pressure against the brush.

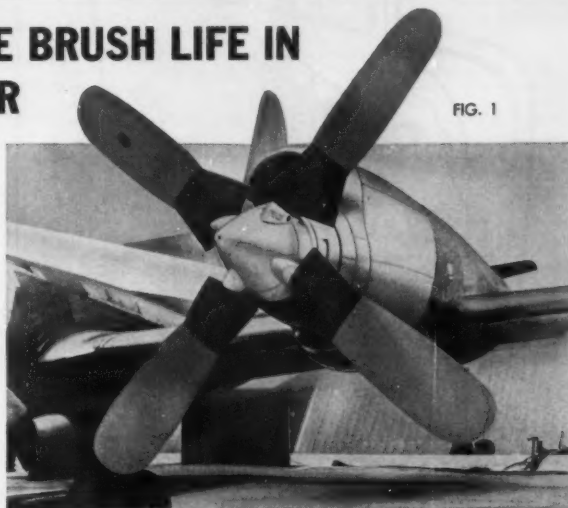


FIG. 1

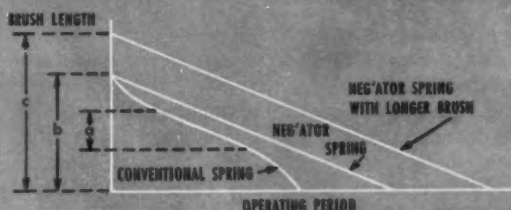


FIG. 2. This curve shows the manner in which brush material is worn away in the course of machine operation. The portion (a) of the conventional spring curve is the region of lowest rate of mechanical and electrical wear. The remaining portions of the curve depict rapid electrical and mechanical wear and poor commutation. This short useful life can be somewhat extended by providing the machine with the necessary contrivances for "resetting" the spring periodically, provided it is practical and convenient to afford such attention, and the skill is available to judge the proper setting. Until the development of the NEG'ATOR brush spring, this method was employed to gain the most efficient utilization of the effective length (b) of brush material that human skill could provide.

By employing the NEG'ATOR spring with a brush of the same length, a low, unvarying rate of wear can be held without any attention, once the correct pressure rating is decided upon, and the proper NEG'ATOR spring installed. Thus what had previously been a theoretical goal—the middle curve above—was achieved in practice, and with it, improved commutation, elimination of a maintenance operation, and removal of adjusting devices from the design of the machine.

Effective use of NEG'ATOR brush springs is not limited to a portion of the spring length; furthermore longer brush springs can be used, because additional length does not represent additional pressure at the beginning of the brush period. Therefore, a longer brush (c) can be installed, and this, in conjunction with the great reduction in rate of wear, further extends the operation time between brush changes, as represented by the upper curve.



## NEW AUTOMOBILE WINDOW-LIFT MECHANISM

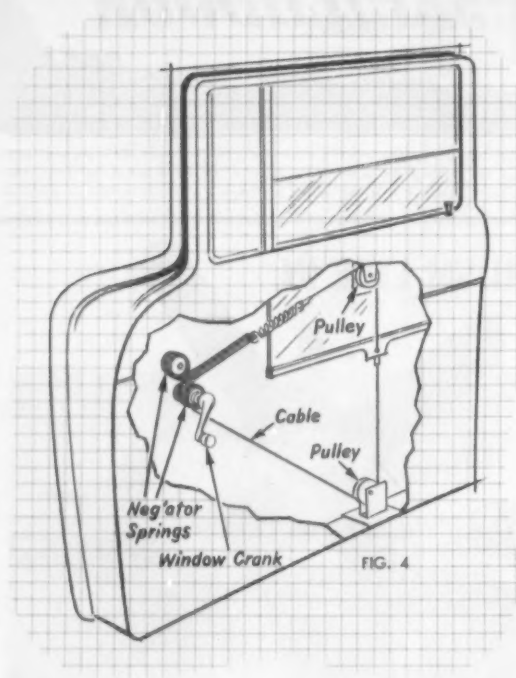


FIG. 4

Used as a counterbalance, the NEG'ATOR spring offers unusual advantages. It can save space, greatly reduce weight, and simplify counterbalancing systems. For instance, two NEG'ATOR springs can be used back-to-back to counterbalance a weight. By adding a crank handle to one of the NEG'ATOR drums, the drum can be rotated and the weight raised and lowered. Without referring to the mathematics actually involved, it can be said that the spring force and weight counterbalance each other—the weight remaining stationary in any position with the aid of external friction forces to stabilize it against "drifting" up or down.

Fig. 4 shows a practical, counterbalancing application using this type of mechanism. In this case, a NEG'ATOR mechanism is used to operate automobile and similar windows. The crank, when turned, will raise or lower the window, the weight of which is balanced by the NEG'ATOR springs. Any friction resisting the upward motion of the window will increase the tension in the NEG'ATOR springs and require that equivalent force be applied to the operating crank. In the case of downward motion, any friction present will develop a force in the cable which will be transmitted to the drum and to the operating crank.

## CAMERA WINNERS

Many faithful SKETCHBOOK readers took notice of our plea in Issue 17, to help us make a nomenclatural breakthrough. The long, thin NEG'ATOR motor, see Fig. 5, so much in need of an unconfusing name (not a trade mark) will probably be called the "slim biaxial motor," or just slimline motor. However, Mr. Robert Marie of Perfect Circle Corporation, Hagerstown, Indiana, and Mr. John E. Ellison of 39 Lawton Road, Manchester, Connecticut, will receive new NEG'ATOR-driven movie cameras of a popular make. Their entries—"power scroll" and "reversed scroll spring motor" were judged to have an edge over some very similar entries. Many other useful or technically well-conceived names qualified, and a number of very clever entries would have placed well had this been a trade-mark contest.

NEW BULLETIN 310f describes Hunter's line of stock reels and NEG'ATOR motors and clamps. Included are specifications and prices. Copies are available on request.

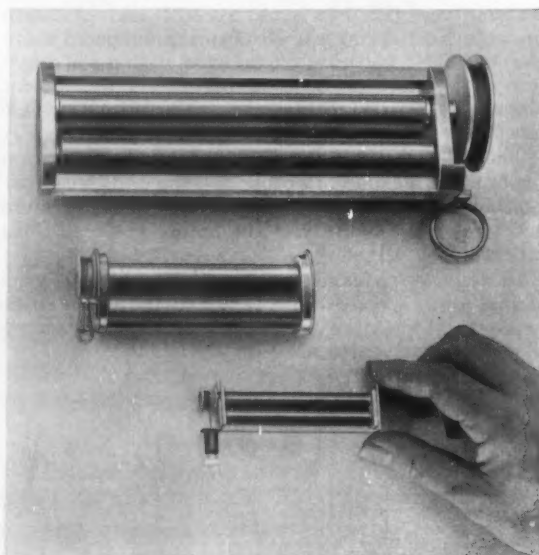
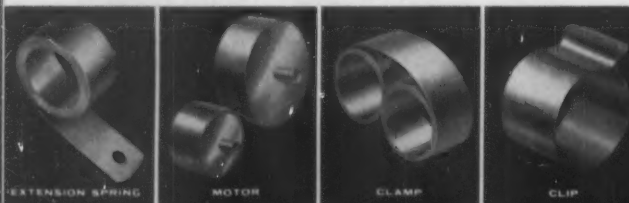


FIG. 5. Here are some new models of Hunter's slim NEG'ATOR motors suitable for mounting in long, thin cavities, or flat unusual available spaces.

H555B—3M—860DB



## HUNTER SPRING COMPANY

A Division of American Machine and Metals, Inc.

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For an additional copy of this sketchbook Circle 438 on Page 19

# STONE AGE or JET AGE

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## #8 HONEYCOMB AS A RADIO FREQUENCY NOISE FILTER

The use of metallic honeycomb in attenuating RF noise is an example of honeycomb's unique properties combining to provide several required end results. Honeycomb is extremely effective in this application, not only because of its ability to filter out radio frequency noise, but because it provides an extremely low pressure drop whether directionalizing air flow or merely serving as a grille. In other instances, honeycomb's RF filter properties combine with its light-directional or light-diffusing properties to place the sources of light in a well-lighted test room *outside* the electrically shielded area. Through correct choice of cell size and cell depth, all properties will operate near optimum levels.

### Honeycomb at High and Low Frequencies

Two conditions may be critical in the attenuation of RF noise, although not usually in the same installation. The first concerns energy at the higher frequencies. Here, the cut-off frequency, or maximum frequency at which aluminum honeycomb will effectively block energy radiation, should be well above any frequency actually encountered. The cut-off frequency is a function of the cell size and cell depth of the honeycomb filter. Cell sizes are available in  $\frac{1}{4}$  inch and  $\frac{3}{8}$  inch in visual-grade honeycomb and down to  $\frac{1}{8}$  inch in the less uniform structural grades, with cell depth as great as 24". In practice, the honeycomb most commonly used is a  $\frac{1}{4}$ -in. cell with a cell depth of  $\frac{1}{2}$ " to 1".

The second critical condition of attenuation is at the low frequency end of the radio noise spectrum. In this area, choice of materials is more limited, since the shielding may require material of higher permeability, such as stainless steel or iron. Correct selection of material, cell size, cell depth and foil gauge, however, will assure effective frequency attenuation.

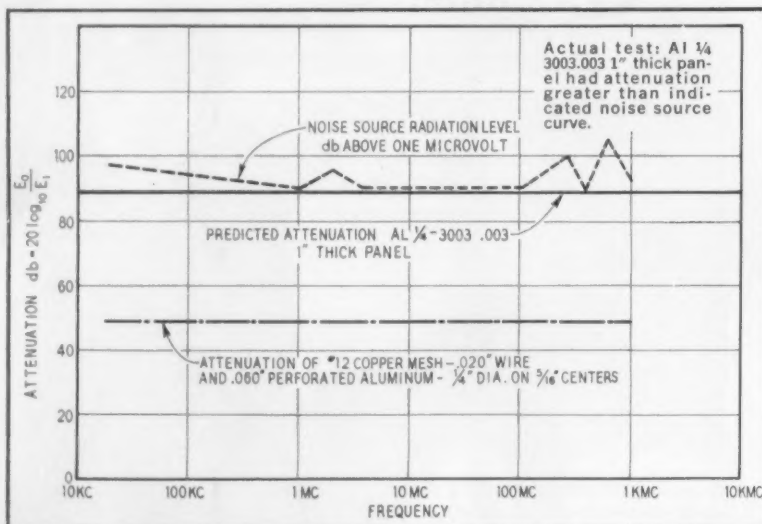
### RF Shielding and Light Transmittal

Where light is to be transmitted through an RF shield, the honeycomb filter must first be able to perform its primary electrical function. For signaling devices, where a beam of parallel light is passed through the

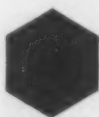
honeycomb louver in a direction parallel to the cell axes, the correct combination of cell size and depth are not critical. For general illumination, however, in a full-lighted ceiling, the ratio of cell depth to cell size must be kept as low as possible, the honeycomb panel must be electrically grounded, and proper finish must be used on the cell walls. The light transmission properties of aluminum honeycomb are primarily a function of the cut-off angle (the angle whose tangent is the ratio of cell depth to cell size), relative position of the honeycomb at light sources, and the reflectance of the floor, walls, and ceiling.

As an example of honeycomb's light transmission properties, a typical Coefficient of Utilization (light transmission efficiency) for a large room would be about .40, assuming the installation of honeycomb with a cell depth of .433 in., cut-off angles of 60°, and optimum plenum conditions. A light level of 100 foot-candles with a Visual Comfort Index of 96 would be quite practicable in this installation. Increasing the cell depth would lower the Coefficient of Utilization, but would give an even higher Visual Comfort Index.

If your design problems could benefit from additional information about the RF shielding and light-directionalizing properties of honeycomb, send for TSB-112, "RF Shielding Properties of Metallic Honeycomb"; HLB-101, "Lighting Properties of Etched HONEYLITE"; and TSB-102, "Air Directional Properties of Honeycomb". Write Dept. 8-C.



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6788

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Spicer resilient propeller shaft assemblies have been used successfully for years in rapid transit cars, street cars, engine dynamometer, truck, bus, earthmover and passenger car applications to solve difficult torsional problems.

Spicer rubber-cushioned shafts make it possible for design engineers to "tune out" the vibration and thus produce commercially acceptable installations.

Spicer rubber-cushioned propeller shafts offer these additional advantages:

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- 2 The cushioning effect prevents clatter, rattle, and backlash noises.
- 3 Increased life of bearings, gear teeth, splines, and other components due to the reduction of high impact and torsional loads.
- 4 Reduction of noise transfer.
- 5 Axial flexibility to cushion forces resulting from length changes.

Product knowledge and years of experience are available to you through Dana engineers to help solve your torsional problems. Contact them today.



International 295 Payscraper, equipped with a Spicer rubber element shaft, at work on the Interstate Highway System.



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## LAMINATED PLASTICS *What they are, where they can be used*

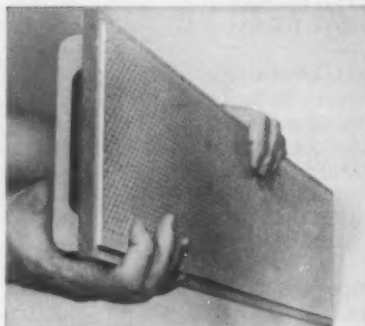
Taylor laminated plastics, also known as reinforced plastics, are thermosetting-type materials formed by impregnating paper, cotton cloth, asbestos, glass cloth, nylon or other base materials with synthetic resins and fusing them into sheets, rods, tubes and special shapes under heat and pressure. These materials exhibit a valuable combination of characteristics, including high electrical insulation resistance, structural strength, strength-to-weight ratio, and resistance to chemical reaction; also adaptability to fabricating operations.

### **Types of laminated plastics made by Taylor**

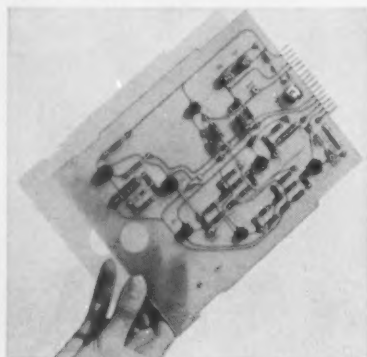
There are four basic types of Taylor laminated plastics commonly specified and used throughout industry today. They are as follows:



**Phenolic Laminates.** Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde resins. These provide strength and rigidity, dimensional stability, resistance to heat, chemical resistance, and good dielectric characteristics. Some Taylor grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Others are widely used in terminal boards, switchgear, circuit breakers, switches, electrical appliances and motors. Also in radios, television equipment and other electronic devices; and in missiles as nose cones, exhaust nozzles, and combustion chamber liners.

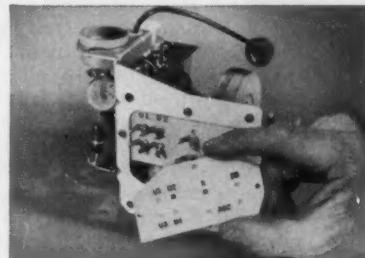


**Melamine Laminates.** Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. Taylor melamine laminates have superior mechanical strength and are especially desirable for their arc-resistant qualities. Good flame and heat resistance, good resistance to the corrosive effects of alkalis and most other common solvents, besides other favorable characteristics. Typical applications include arc barriers, switchboard panels, and circuit-breaker parts in electrical installations.



**Silicone Laminates.** Continuous-filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F. continuous) with excellent electrical and mechanical properties. They are primarily used in high-temperature electrical applications and high-frequency radio equipment.

**Epoxy Laminates.** Continuous-filament woven glass fabric or paper impregnated with epoxy resin. Glass-fabric grades are designed for use in applications requiring high humidity-resistance, good chemical resistance,



and strength retention at elevated temperatures. Paper grades are used under high-humidity conditions where resistance to acids and alkalis is required. Both grades are characterized by good dielectric strength, low dielectric losses, and high insulation resistance even following severe humidity conditions.

• • •

Recent technical advances in the bonding of various metallic and nonmetallic materials to laminated plastics have opened up new design opportunities. It is now possible to bond virtually any compatible material with a laminated plastic to form a composite which combines the advantages of both. One of the first composite materials was a copper-clad laminate used for printed circuits. More recent composite laminates, usually manufactured to customer specification, include the following: Taylorite® vulcanized fibre-clad, rubber-clad, asbestos-clad, aluminum-clad, beryllium-copper-clad, stainless-steel-clad, magnesium-clad, and silver-and gold-clad. Any one of these materials can be sandwiched between sheets of laminates, too, and can be molded to fit specific requirements.

Send for complete information about any or all of these Taylor laminates. And remember Taylor's new selection guide will simplify your problems in choosing the right laminate for your specific application. Taylor Fibre Co., Norristown 47, Pa.

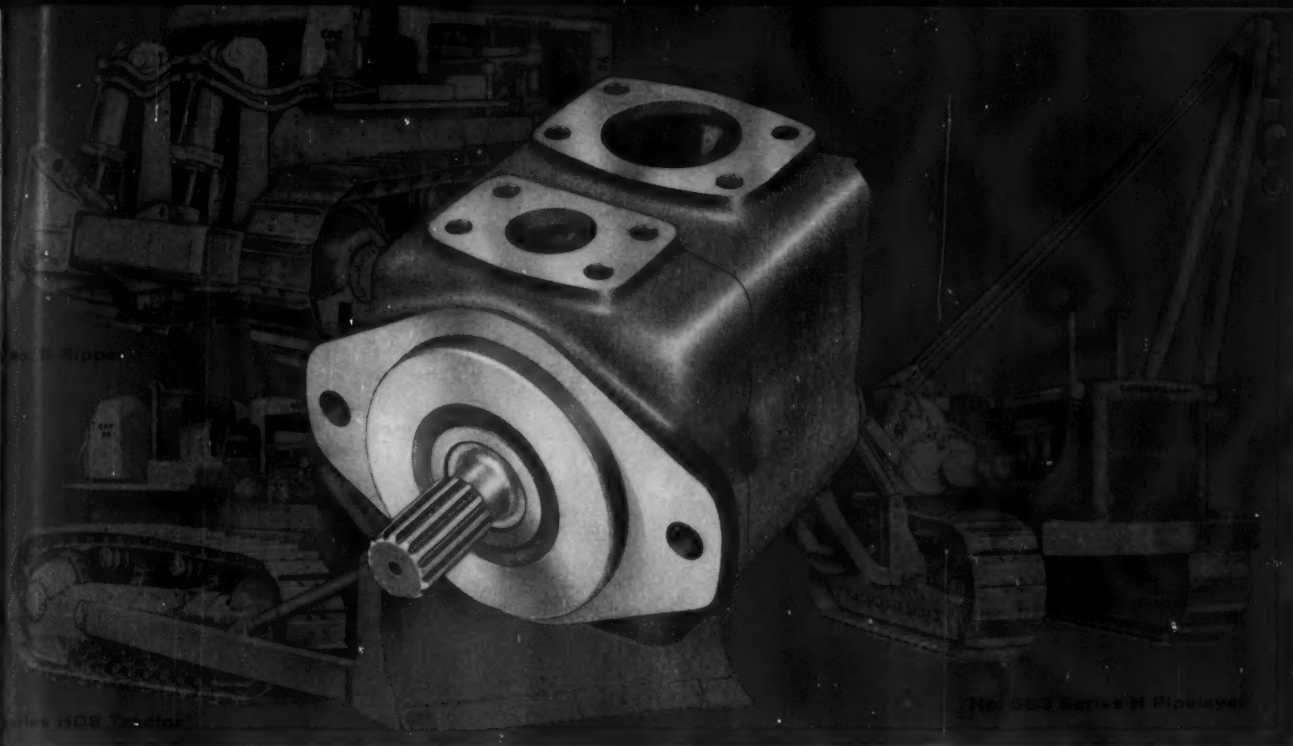
**Taylor**  
LAMINATED PLASTICS VULCANIZED FIBRE

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## CATERPILLAR SELECTS VICKERS VANE PUMPS

*"HIGH PERFORMANCE" PUMPS PICKED FOR NEW SERIES H EQUIPMENT*

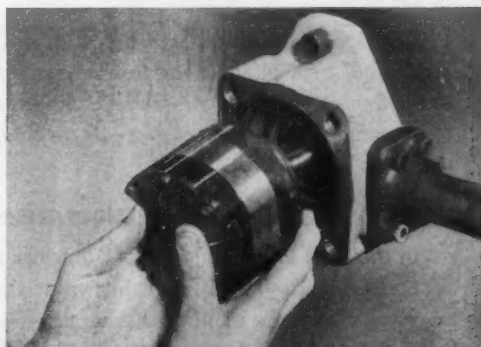
Continuing critical selection and evaluation of all component items used on its machines helps make Caterpillar Tractor Co. outstanding in its field. Thorough engineering, advanced manufacturing, and top-quality materials result in cost-cutting construction equipment . . . the new D8 Series H Tractor, No. 8 Ripper and No. 583 Series H Pipelayer.

To assure dependable hydraulic power on these machines, Caterpillar specifies the Series 25, Series 35 and Series 45 Vickers "High Performance" Pumps as original equipment.

VICKERS "HIGH PERFORMANCE" PUMPS (larger sizes and double pumps soon to be released) represent the most complete range of high speed, high pressure pumps for construction and material handling equipment ever offered. Send for **BULLETIN M-5108** for further information and performance characteristics.

### Complete pump overhaul in 10 minutes in the field...

Replacement cartridges for "High Performance" pumps contain all normal wearing parts and insure "As New" results. Following vehicle manufacturer's instructions, cartridge can be quickly changed without removing pump from vehicle and usually without disconnecting hydraulic lines. Caterpillar Dealers provide cartridges and replacement service in the field.



5282

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Circle 443 on Page 19

# DODGE HAS MORE PROVED BEARINGS THAN YOU HAVE BEARING PROBLEMS!

It pays to buy from a line of stock bearings—bearings that have been proved in thousands of installations similar to yours. You benefit by getting known dependability; and you get the important savings of high quality at production price.

## PIN-POINT SELECTIVITY

Dodge has supplied mounted bearings to industry for over three-quarters of a century. Dodge bearings have always kept pace with improved production practices. Each new condition of service has been met by Dodge as it has arisen, with the result that the Dodge line contains mounted bearings to meet almost every service requirement with pin-point accuracy.

High load, high speed, excessive dust, moisture, corrosion, high or low temperatures, continuous operation—you name it!—such conditions and their combinations are met every day with Dodge bearings.

## BROAD LINE—WIDELY DISTRIBUTED

In the great variety of mounted bearings developed by Dodge, you will most likely find the precise unit to fit your requirements ideally—without paying for features you do not need. And if your requirements call for several types of bearings, there is an advantage in having them of common design, such as Dodge offers.

The Dodge line is probably broader than any other line of mounted bearings in America. And of special importance to machinery manufacturers, it is the most widely distributed line. There is always a Dodge bearing of the right type and size near at hand.

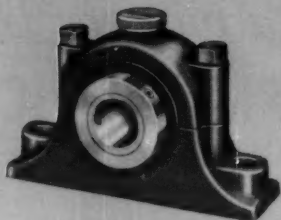
You can check this with your local Dodge Distributor. Ask him—or write us for the Dodge Bearing Bulletin.



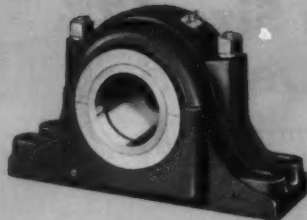
In addition to tapered roller, spherical roller and ball bearings, Dodge builds many types of sleeve bearings. Here is the "large and small" of the sleeve type bearings carried in stock—ranging from an 8-in. Sleeveoil weighing over 1200 lbs. to a 1/2-in. solid journal bearing weighing 9 ounces.

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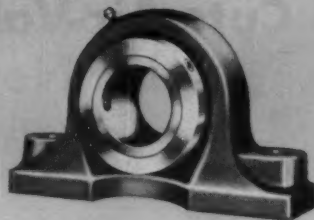




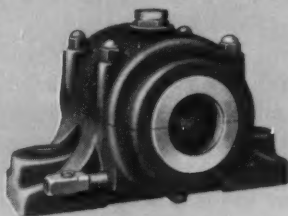
**DODGE PILLOW BLOCKS WITH  
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**DODGE SPHER-ALIGN PILLOW BLOCKS  
WITH SPHERICAL ROLLER BEARINGS**



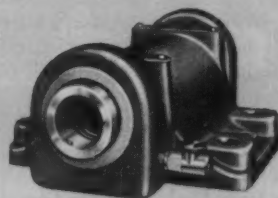
**DODGE BALL BEARING  
PILLOW BLOCKS**



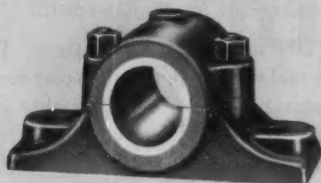
**DODGE SLEEVOIL  
PILLOW BLOCKS**



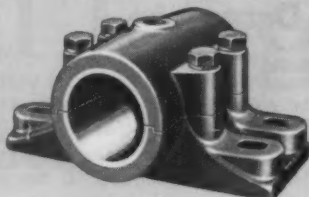
**DODGE BRONZOIL  
PILLOW BLOCKS**



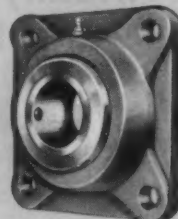
**DODGE BRONZE BUSHED  
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**DODGE HEAVY RIGID  
PILLOW BLOCKS**



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● **Dodge Pillow Blocks with Timken Tapered Roller Bearings.** America's quality pillow blocks. Assembled, lubricated, adjusted and sealed at the factory. 5 types for varying needs.

● **Dodge Spher-Align with Spherical Roller Bearings.** Rugged heavy duty, compact, inherently self-aligning. Exclusive Micro-Mount simplifies installation.

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● **Dodge Bronze Bushed Pillow Blocks.** Quiet fan and blower pillow blocks with two bronze bushings of high lead content mounted in one cast iron housing.

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**CALL THE TRANSMISSIONEER**—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the white pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

# DODGE

→ of Mishawaka, Ind.



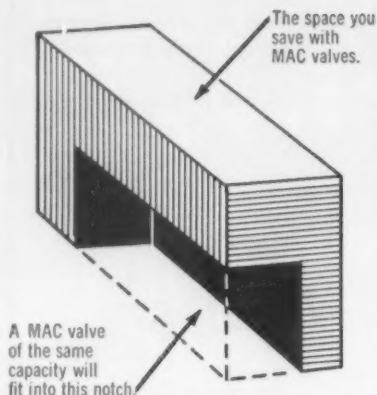
## Cuts Air-Valve Size 67% with New Design

*Also Boosts Performance, Life,  
and Ease of Service*

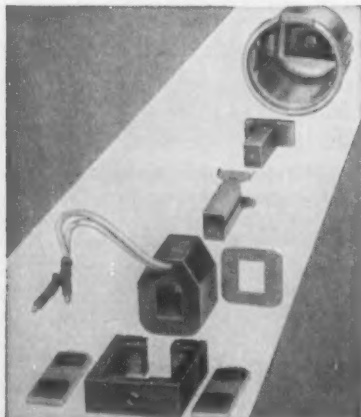
A remarkable new line of pilot-operated air-valves—the MAC series 300—cuts space requirements to  $\frac{1}{3}$  of that normally required for valves of equal capacity rating.

Not only is the valve extremely simple in operation, reducing cost, but the three moving parts can be replaced in a matter of 1 to 2 minutes without special tools. Life of moving parts is rated at 30,000,000 cycles, minimum.

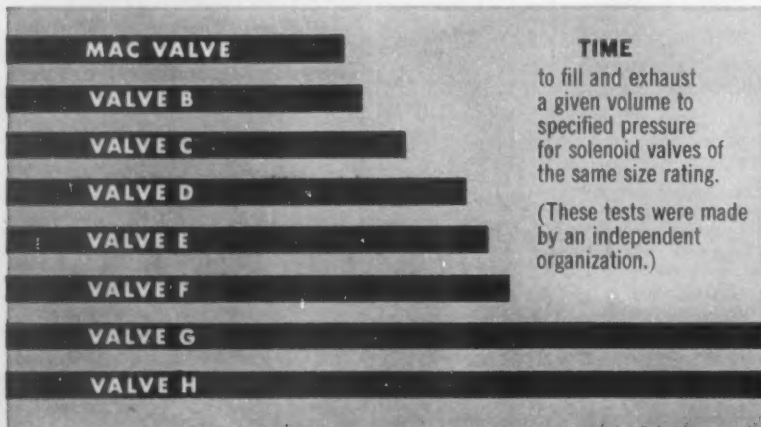
The story of how this was accomplished, together with valve sizes and specifications, is contained in Bulletin #300A available from Mechanical Air Controls on request.



## New Solenoid Boosts Valve Life —Virtually Foolproof, it also has Lighter Draw



A virtually failure proof solenoid which can be completely assembled or taken apart without any tools—but which can't be assembled wrong has been developed by Mechanical Air Controls. It has no welds to break or crack. It has no screws, nuts, bolts or other fasteners to work loose. It has a fully encapsulated water and oil resistant coil. There is no wiring through air valve body. The connections just plug in. The entire assembly floats on rubber mounts, the rubber being in shear. The solenoid has a lower draw because of the lighter push required. The design provides for both locking and manual jogging. It is standard on every MAC series 300 air valve.



## advances in PNEUMATICS



## designing an air valve...

There are two ways to design air-valves. One is for a specific job, and no more. For example, a valve in a missile usually has to function only once. Wear life is no problem. The other way is to design a valve for the toughest job it might face and then use it on easier jobs, too.

Any engineer would prefer the second way, but he wonders "Won't it cost too much?"; or "Won't I be criticized for providing more performance or life than needed?"

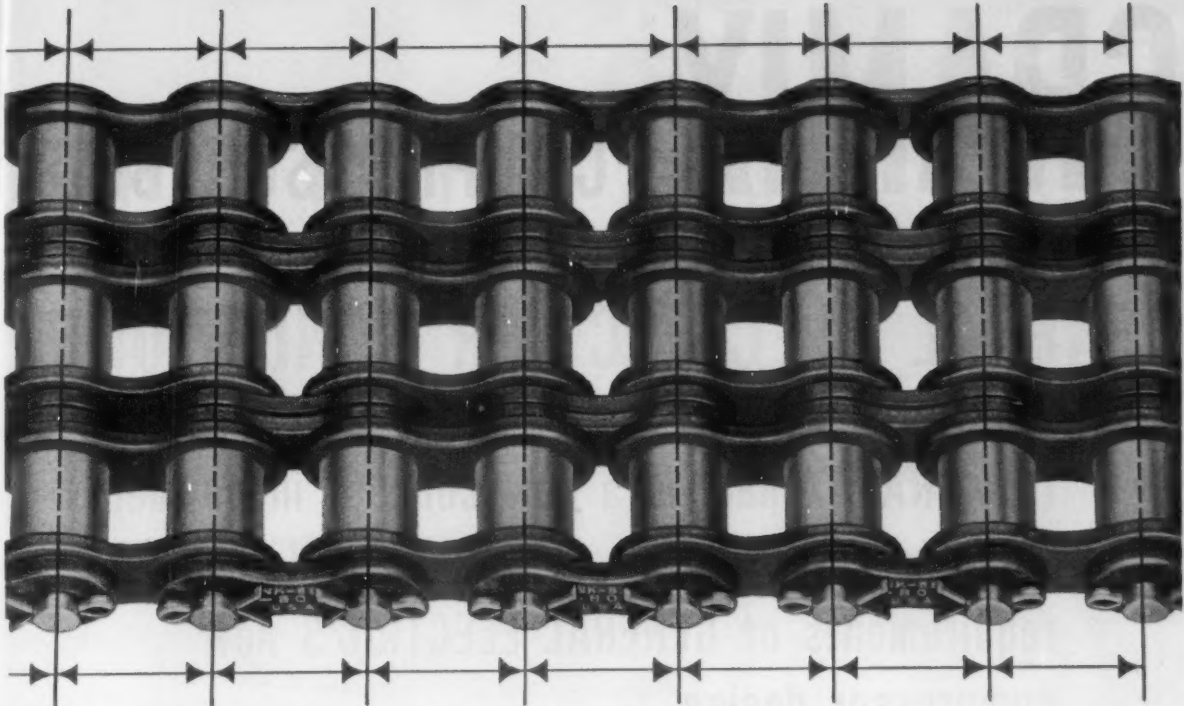
His worries are pointless. The second way doesn't have to cost more. Extra performance and quality can be a free "plus." If you design air-valves for the TOUGHEST jobs they can encounter (as we did at MAC) you can naturally get a simpler, more compact, easier-to-service valve; plus extra performance reserve—all AT LOWER COST.

Why? Once the valve licked the toughest application—where speed, reliability, serviceability and life were MOST vital—we simply standardized for mass production. That's how we wound up with a better and lower cost valve . . . the series 300.

*J. D. Luning*  
President



**MECHANICAL AIR CONTROLS, INC.**  
10030 Capital, Oak Park • Detroit 37, Michigan



Precision controlled link pitch throughout  
LINK-BELT roller chain means

# equal length... equal strength

**How pre-stressing ensures uniform  
load distribution of multiple-width  
LINK-BELT roller chain**

Pre-stressing is one of the reasons why Link-Belt multiple-width precision steel roller chains easily handle the grueling loads common on today's drives. It seats and cold works the chain joint parts, assuring equal load distribution across the chain, minimum initial elongation, increased fatigue life.

Pre-stressing is just one of many "extras" that contribute to the *greater dynamic strength* of Link-Belt roller chain. Others include: close heat-treat control, lock-type bushings, shot-peened rollers, pitch-hole preparation. For details see Book 2657.



**PRE-STRESSING MACHINE** provides the pull that "sets" the parts of Link-Belt multiple-width roller chain. Besides assuring uniform load distribution, pre-stressing eliminates application difficulties on fixed center drives because the chain leaves the factory at precise operational length.

# LINK-BELT



**ROLLER CHAINS AND SPROCKETS**



**BOOK 2657** has 154 pages of roller chain data. Contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your phone book.)

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

15,301-A

# GRAMIX<sup>®</sup> COMPRESSOR BODY

## GENERAL ELECTRIC AIR CONDITIONER

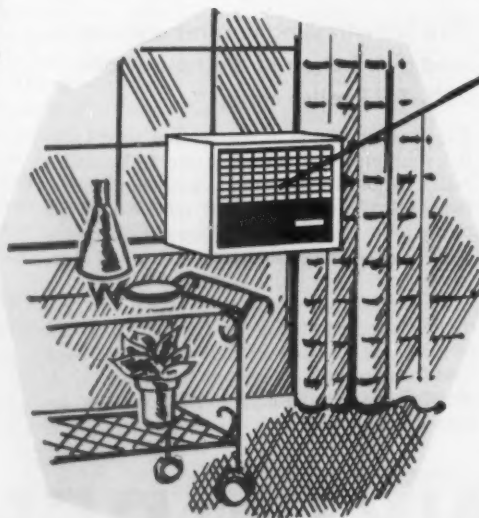
this GRAMIX part is a new concept in powder metallurgy techniques . . . engineered to meet requirements of GENERAL ELECTRIC'S new compressor design

This large, complex shaped compressor body which is employed in air conditioners manufactured by General Electric is an outstanding example of a GRAMIX part engineered and produced to exacting specifications. As in all GRAMIX products of powder metallurgy, the alloy was created to meet exacting physical properties required in this particular application. Correct briquetting, controlled sintering procedures, precise finishing operations and rigid quality control throughout the manufacturing process assures General Electric uniform, dependable GRAMIX parts. The production of this body as a product of powder metallurgy has also enabled General Electric to effect important design changes in their air conditioning units.

GRAMIX engineers have the experience, the techniques and the equipment to produce top quality products of powder metallurgy. No matter what type of part you need, no matter what characteristics that part must possess, it will pay you to select GRAMIX . . . and get both "job-engineered" alloys and quality-controlled production to meet each specific operating requirement.



Write today for these helpful engineering manuals. No. 18 covers design and metallurgical requirements and alloy selection of GRAMIX bearings. No. 19 covers GRAMIX Machine Parts and No. 21 contains general information on GRAMIX products from Powder Metallurgy.



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GRAPHITAR<sup>®</sup> CARBON-GRAPHITE • GRAMIX<sup>®</sup> POWDER METALLURGY • MEXICAN<sup>®</sup> GRAPHITE PRODUCTS • USG<sup>®</sup> BRUSHES

# IS VITAL PART IN



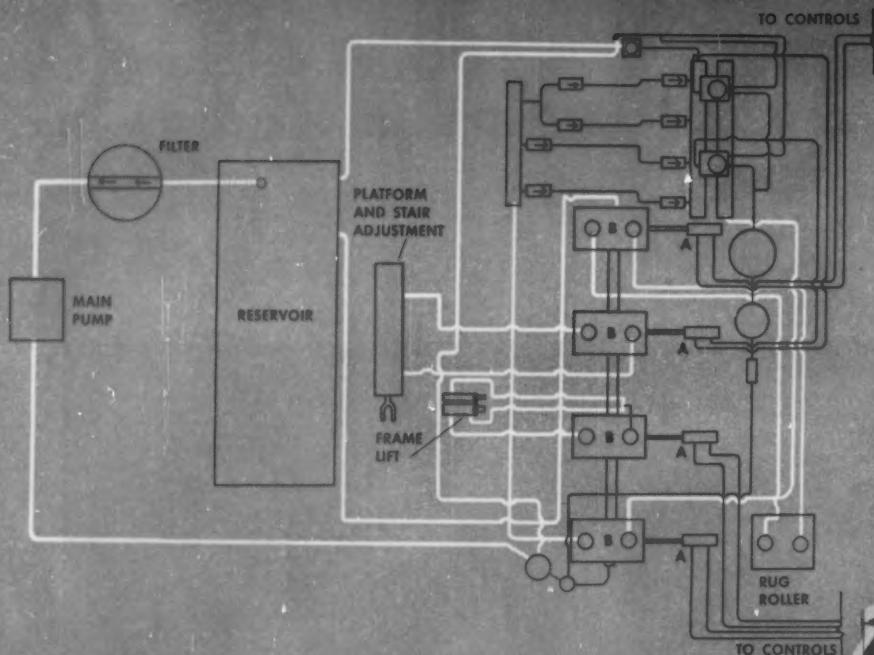
This part is shown  $1\frac{1}{2}$  times size. Actual weight:  $2\frac{1}{4}$  lbs.

X-271-2

## GRAPHITE COMPANY

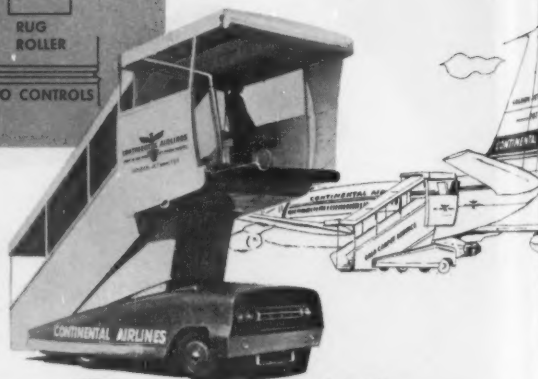
DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN





Simplified schematic of hydraulic system shows Gates Hydraulic Hose in white line, other elements in black. Air from 15-psi pneumatic control system enters slave cylinders A, activating high-pressure hydraulic valves B, which in turn operate mechanisms for platform and stair adjustment, frame lift, and rug roller. Hydraulic valves also operate stabilizers (not shown).

Deluxe passenger ramps manufactured by Bil-Jax, Inc., of Archbold, Ohio, for Continental Airlines "Golden Jet" service feature completely self-contained operation: raising and lowering of ramp, rolling out Gold Carpet, and driving truck, all from a single set of controls.



# **bil-jax inc. selects Gates Hose to speed "Gold Carpet" service!**

Chosen by Continental Airlines to develop and produce the special ramps required for the carrier's Boeing 707 loading operation, Bil-Jax in turn selected

Gates Hydraulic Hose because of "...the quality and reliability of the product, its availability, and the technical assistance available from Gates representatives."

**Immediately available in all major markets.** Gates Hydraulic Hose —built to meet or exceed SAE specifications—is available nation-wide in wire-braided and horizontal-braided construction in a complete range of sizes, for medium-pressure or high-pressure use. Ask your nearby Gates Distributor for Gates Hydraulic Hose Assemblies booklet, IH 43.



**The Gates Rubber Company • Denver, Colorado**  
**Gates Rubber of Canada Ltd., Brantford, Ontario**

The Mark of *Specialized* Research

TPA 467

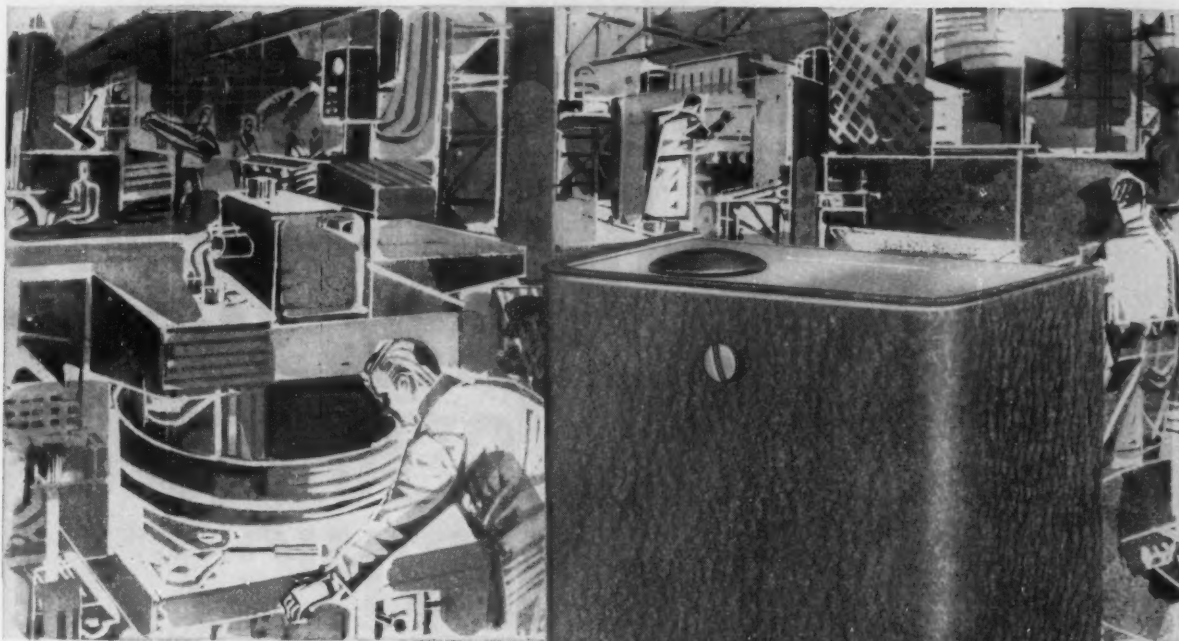
# **Gates Hydraulic Hose**

Made in a Full Range of Sizes  
 Medium-Pressure, High-Pressure

Circle 448 on Page 19

From Honeywell

## A compact inexpensive controller



- Automatic temperature control
- Automatic pressure control
- Automatic control of liquid level
- Automatic humidity control

Now—a transistorized controller that's versatile enough to be used in many applications. Small, compact, with complete repeatability. No tubes, no warm up time, gives instant reaction. Works with sensors that can be thermistors, probes, resistance bulbs, pressure transducers or humidity elements. Can be used in such varied applications as packaging machines, injection molding machines, cooking vats, tire recapping, ice cube makers, and tanks, etc. Has

Exclusive Honeywell Versa-Tran replaces old fashioned mechanical control at low cost.

a temperature control range from minus 60 degrees to plus 1400 degrees F.

The Versa-Tran is the result of traditionally superior Honeywell engineering. For information, call your nearest Honeywell office and our industrial control sales engineer will call. Or write: Minneapolis-Honeywell, Department MD-8-24, Minneapolis 8, Minnesota. In Canada, write: Honeywell Controls Ltd., Vanderhoof Avenue, Leaside, Toronto 17.

# Honeywell

**75<sup>th</sup>**  
PIONEERING THE FUTURE  
**YEAR**



*First in Control*

SINCE 1885

# ANKER-HOLTH CYLINDERS FULFILL RIGID WESTINGHOUSE REQUIREMENTS IN NEW WEAN GEARLESS 'FLYING PRESS'





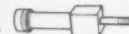


A new gearless "Flying Press", especially designed and built by Wean Equipment Corporation for Westinghouse Electric Corporation's Standard Control Division at Beaver, Pa., is equipped with Anker-Holth cylinders.

The press operates at twice the production rate of the presses previously used for this operation. It offers reduced die maintenance and permits simplified over-all machine maintenance.

Necessary components in the press are rugged, reliable cylinders for pulling the lower bed out of alignment in event of cobble or mis-feed emergencies. Wean has found that Anker-Holth cylinders fulfill this rigid and exacting requirement.

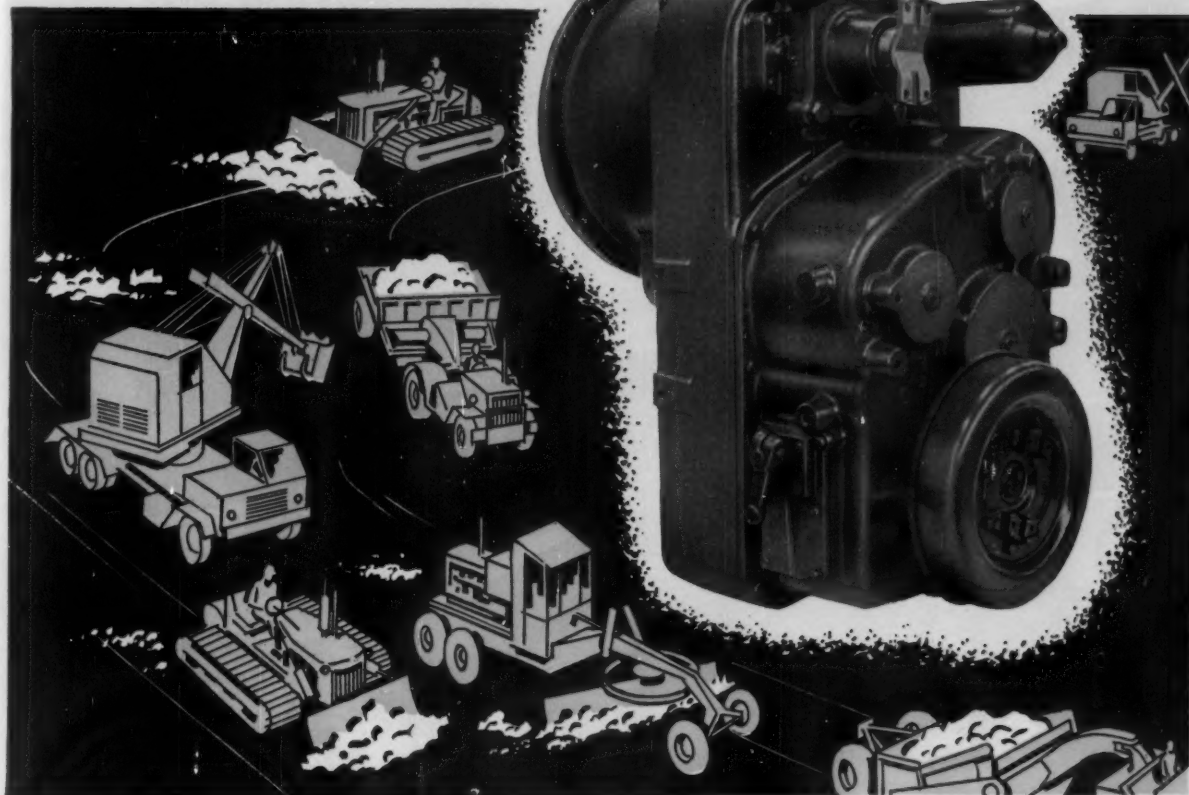
Chances are, Anker-Holth has the answer to your power cylinder needs, too. You may choose from the world's widest selection of standard models, available in all mountings. Special cylinders can be designed to your exact requirements, usually assembled from a combination of standard parts.

 YOU HAVE A BETTER CHANCE  OF FINDING THE EXACT POWER CYLINDER  
YOU NEED  IN A STANDARD  PRODUCTION MODEL  AT ANKER-HOLTH

## ANKER HOLTH

DIVISION, THE McDOWELL-WELLMAN COMPANIES  
2723 CONNOR STREET, PORT HURON, MICH., U.S.A.

More Performance At Less Cost:



## HYDRA-DRIVES® CDB POWER SHIFT TRANSMISSION

*A torque converter...and 4-speed transmission in one compact package!*

Proved in hundreds of vehicles for four years, these units assure top work output of heavy-duty equipment... at a lower initial cost than other models of comparable performance. Engine lugging and heavy shock loads are eliminated. A 3 to 1 torque multiplication makes starting fast and effortless—even with heaviest loads.

Just a flip of the operator's lever accomplishes power shifts within each range and without any interruption of the power flow.

With four speeds forward and reverse, the CDB Hydra-Drives Power Shift Transmission is ideally suited for vehicles which must travel in both directions during a normal work cycle. Rated at 550 ft. lbs. input torque, it can be used with a wide range of internal combustion engines up to 250 H.P.

The CDB model illustrated above is used in connection with a size "C" drop box.

A BDB model is also available, for use with a size "B" drop box on equipment up to 175 H.P.

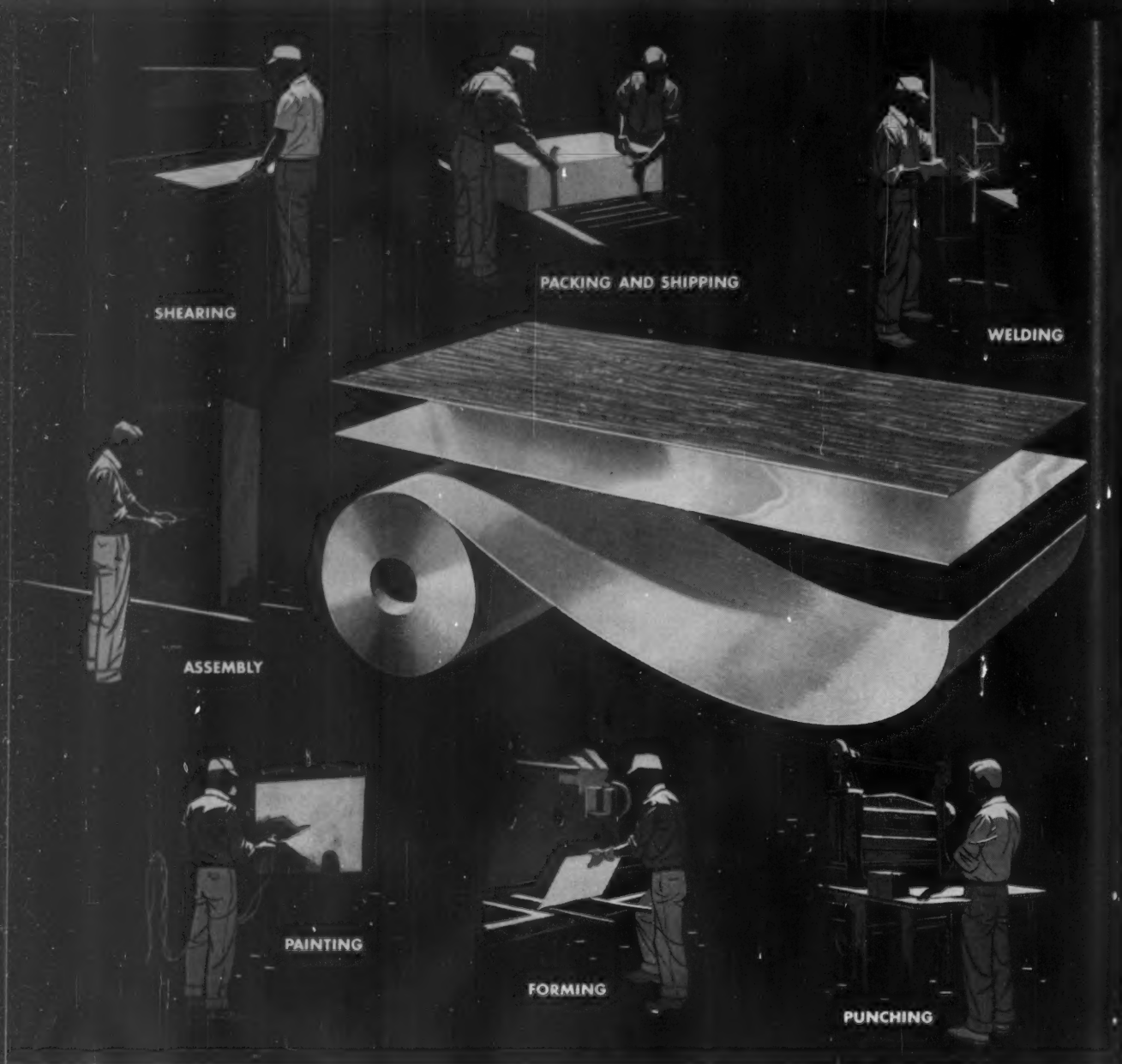
*Another Product of...*

**ROCKWELL-STANDARD**  
CORPORATION



Transmission and Axle Division, Detroit 32, Michigan



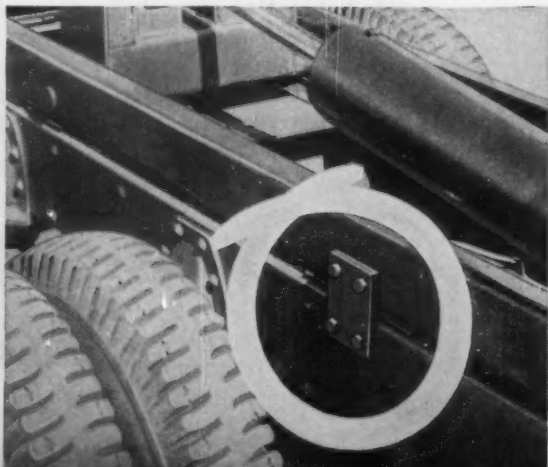


**MACHINING HIGH-STRENGTH METALS:** Republic Titanium was cut, ground, tapped, spot welded, heat treated, and hand forged by the Crane Co., Chicago, Ill. Parts produced were valve components—lower stems, disc stem rings, and disc and stem ring pins—used in Freeport Nickel Company's new \$119,000,000 nickel-cobalt processing facilities. Crane reports, Republic Titanium permitted close-tolerance machining with considerably fewer rejects. Call your Republic representative, or send coupon for data.

Circle 452 on Page 19

**REPUBLIC NYLOK NUTS** hold tight, resist vibration, and grip with a positive lock to anchor dump bodies to the chassis at the Heil Company, Milwaukee, Wisconsin. NYLOK Nuts stay tight in any position—seated or not. Easy to apply manually or automatically. Can be used over and over again. Check your products for application where NYLOK Nuts can do the job better. Send coupon for complete Republic NYLOK fastener information today.

Circle 453 on Page 19



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# REPUBLIC SHEET STEEL FABRICATION "KNOW-HOW"

## *Solves Manufacturing, Assembly, Delivery problems*

Republic's Berger Division complete sheet steel fabrication "know-how" may be the answer in giving your products a new look, new market acceptance, new sales potential.

Berger has experienced engineers and craftsmen, and the facilities and abilities to manufacture sheet steel products from galvanized steels, stainless steels, and the new vinyl coated sheet steels.

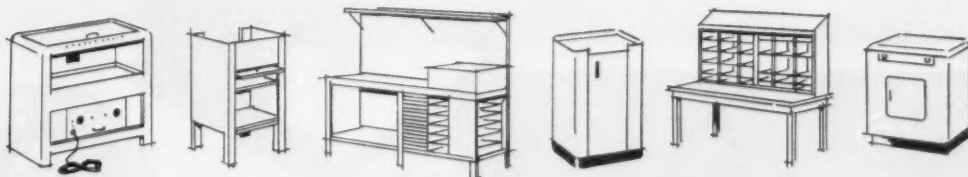
Berger offers a well rounded stock of tools and dies, modern assembly lines for shearing, punching, forming, finishing, and painting. Standard and special arc, spot, and gas welders designed for production line

assembly. Tumbling barrels and plating equipment. Grinders and sanders.

Finest finishing facilities, including Bonderizing and electrostatic paint spray equipment. Finishing conveyors through spray booths, dip tanks, and baking ovens. Automatic material handling equipment. Completely mechanized crating department with conveyor line carton-packaging facilities.

Let Berger Division engineers work with you in designing and developing your product. Use Berger facilities to solve manufacturing and delivery problems. For complete details, contact Berger's Contract Manufacturing Department, today!

Circle 454 on Page 19



FABRICATING GALVANIZED STEELS... STAINLESS STEELS... VINYL COATED SHEETS

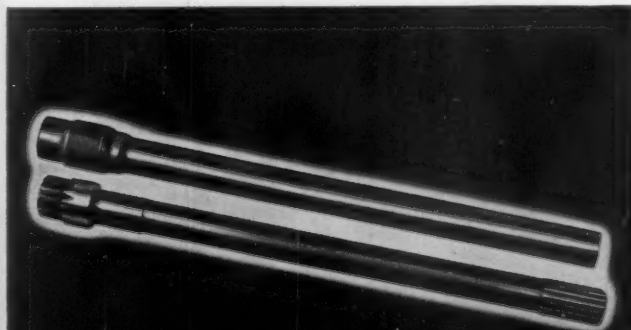


## REPUBLIC STEEL

*World's Widest Range  
of Standard Steels and Steel Products*

**REPUBLIC DIE-FORM BLANKS REDUCE COSTS** because the Die-Form Blank (above) closely approximates the completed part (below), scrap losses are negligible and machining is held to a minimum. Die-Form is a new method of cold forming hot rolled carbon, alloy, or stainless steel bars into multi-diameter blanks ready for final machining. Handling costs for raw material and scrap disposal are greatly reduced. Production rates are increased. Write for data.

Circle 455 on Page 19



### REPUBLIC STEEL CORPORATION

DEPT. MD-9937

1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on the following products:

- ☐ Republic Contract Facilities ☐ Have representative call  
☐ Republic Titanium ☐ Republic NYLOK® Fasteners  
☐ Republic Die-Form Blanks

Name \_\_\_\_\_ Title \_\_\_\_\_

Firm \_\_\_\_\_

Address \_\_\_\_\_

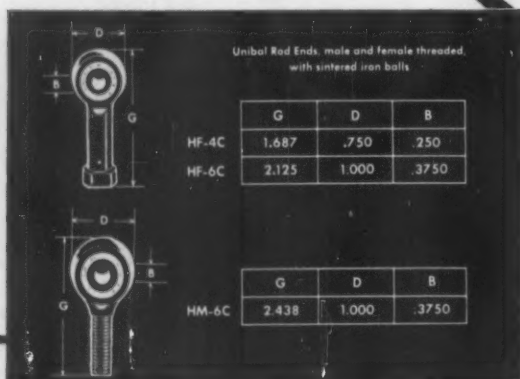
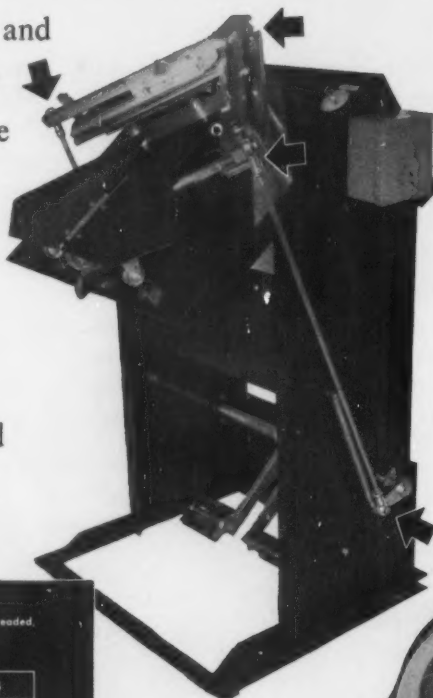
City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_

# How to do it Better for less...

## with **HEIM** Unibal®

### SPHERICAL BEARING ROD ENDS

This is the Collar Shaping and Pressing Machine made by the Reece Folding Machine Company, which is a low-priced, manually operated device used in the shirt trade for shaping and pressing collars after they are sewed together, but before being attached to the shirt.



*Unibal Rod Ends are used in five places, and were chosen for some carefully-thought-out reasons.*

- *Unibal ball joints lower the machining and assembly cost.* A male Unibal is used at the fulcrum of the triangular pressing lever at top center. This allows the pressing plates to be easily lined up with the mating surface without expensive machining to close tolerances.
- *Long wearing qualities reduce replacement costs.* Reece says, "We have been using Unibal rod ends in our machines since 1947, and as far as we know, none have had to be replaced because of wear."
- *Solve design problems economically.* The use of Unibal "gets us out of some tough design problems quite economically, simplifies co-operating parts and makes final assembly easier."
- *Maintain easy, smooth action.* Heim Unibal rod ends are used to transmit motion from the lower shaft to the pressing plates between levers moving in arcs in different planes. They maintain the easy action necessary to manual operation.
- *Correct misalignment in all directions.*

The high quality and special advantages of Unibal Spherical Bearings and Rod Ends can save you time and money in the assembly of your machines. Ask our engineering department how. Send for the Heim complete catalog.

**THE HEIM COMPANY** Fairfield, Connecticut

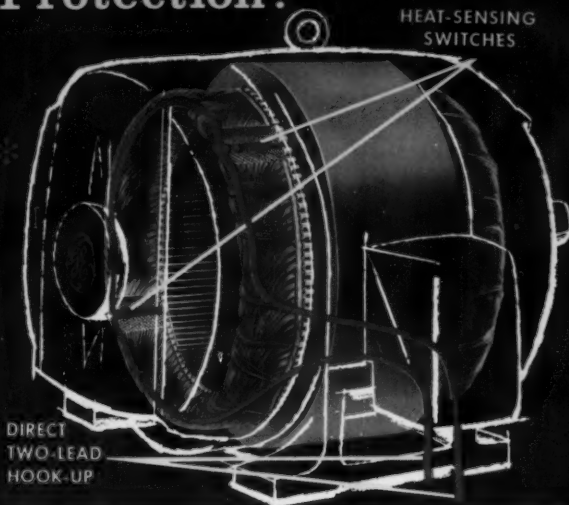
ALL HEIM BEARINGS ARE AVAILABLE THROUGH THE LEADING BEARING DISTRIBUTORS IN THE U. S. AND CANADA

GENERAL ELECTRIC

New Concept in Motor Protection!

Tri-Clad '55'  
Thermo-Tector  
SYSTEM ENDS  
OVERLOAD  
BURNOUT!

Trade-mark of General Electric Co.



General Electric offers a *totally new* type of protection on *all* Tri-Clad '55' motors 7½-125 hp!

Exclusive THERMO-TECTOR system has heat-sensing switches buried in stator windings. Switches shut off motor *only* when stalls, overloads or other

conditions threaten heat damage to motor windings.

Unique THERMO-TECTOR system "anticipation" feature varies motor shut-off point according to rate of winding heat rise. This flexibility allows *maximum motor output* under all conditions.

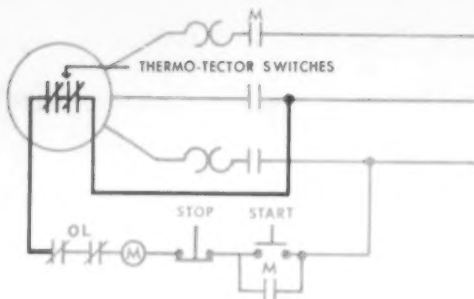
TURN PAGE FOR FURTHER INFORMATION ➡ ➡ ➡



# NEW Tri-Clad<sup>®</sup> '55'

## THERMO-TECTOR SYSTEM

### Allows Full Motor Output— No Wasteful "Safety Margin" Needed



Thermo-Tector system needs no costly amplifying relays, connects directly to any G-E motor controller.

You get full output from Tri-Clad '55' motors with Thermo-Tector system. Variable response feature of heat-sensing switches allows motor to operate right up to safe limits under any operating condition.

Thermo-Tector switches are offered on *all* Tri-Clad '55' motors in frames 254U-445U. For more information, contact your G-E Apparatus Sales Office or write for Bulletin GEA-7092, Section 866-03, Schenectady 5, N. Y.

SMALL AC MOTOR & GENERATOR DEPARTMENT

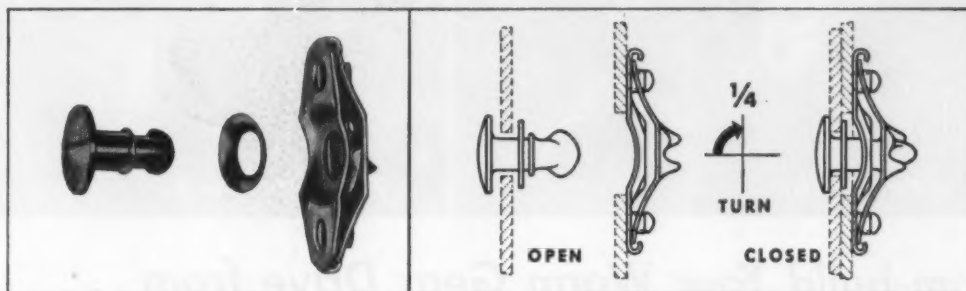
**GENERAL  ELECTRIC**

Circle 457 on Page 19

THIS PANEL CAN BE  
OPENED OR CLOSED  
IN LESS THAN 2 SECONDS

## LION $\frac{1}{4}$ TURN OPEN $\frac{1}{4}$ TURN CLOSED FASTENERS

ARE FAST, POSITIVE, RELIABLE



Installation of the three parts of the Lion Fastener, shown above, is quick but not critical. Unique in design and performance, these mil spec (MIL-F 5591A-ASG) fasteners make possible quick access and smooth positive locking by only a  $\frac{1}{4}$  turn.

### ALIGNMENT NOT CRITICAL

Both stud and receptacle "float" to accommodate misalignment. The hole, which retains the stud, is twice as large as the stud cross-section. This permits a float of .070 in all directions. The leaf spring receptacle also floats to accommodate stud position.

### WIDE VARIATIONS IN STACK HEIGHT

Total sheet thickness may vary as

much as  $+.035$  and  $-.015$  without affecting operation. A Lion stud, specified for .160 total thickness, for example, will accommodate any stack height between .195 and .145.

### SWAGED-NOSE STUD

Extra strength and smooth operation are made possible by the swaged-nose design. All the metal in the stud goes to work. There are no thin cross pins, holes or milled slots to weaken the cross-section. Case hardening is further assurance of long, trouble-free service.

### WIDE VARIETY

Lion Fasteners are available in 3 sizes—No. 5, No. 2, and Miniature.

An assortment of head styles are supplied—oval, flush, wing, ring, notched or knurled—according to individual requirements.

**FREE!**

**FASTENER  
HANDBOOK**



Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and other special fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pennsylvania.

©1959



MISSILES



CIVILIAN



MILITARY

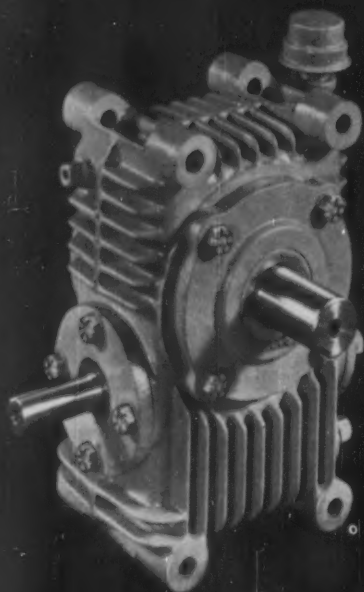


COMMERCIAL

**LION Aviation FASTENERS**

one of the

**SOUTHCO**  
**LION**  
**FASTENERS**



2, 2 1/2" center distance



3, 3 1/2" center distance

4, 5, 6

**Custom-build Your Worm Gear Drive from . . .**

# OVER 200,000 STOCK C

The four "worm-under" speed reducers shown above represent only eleven sizes of standard, Cone-Drive units. Also standard are 15", 18", 22", and 24" center distance units. Cone-Drive worm gear reducers are available in ratios from 5:1 to 4900:1 and up to over 1200 HP capacity. All units feature the double-enveloping principle in which the worm and gear wrap around each other for greatest tooth contact, strength, smoothness, shock-resistance and quietness of operation.

All Cone-Drive worm-gear reducers feature heavy, ribbed, nickel-iron castings for maximum strength and heat dissipation. Heavy-duty taper roller bearings provide anti-friction support to both worm and gear shafts. Chrome-molybdenum-nickel steel worms and tin bronze gears provide long life

and high strength. The Cone-Drive design also gives the exclusive benefit that, in service, both gear and worm tend to regenerate their true form . . . worm and gear wear "in" rather than "out."

## Standard Options

By selecting various options, standard units can be obtained to fit almost any drive requirements. By taking advantage of these options in the early design stages, you can often simplify design and improve performance, too. Including size and ratio ranges and options available, Cone-Drive Gears offers over 200,000 worm-gear speed reducer combinations that are standard, shelf-hardware items. Special sizes and ratios can be furnished on a quotation basis. Write for Bulletin CD-218 for complete details.

## CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

7171 E. McNichols Road • Detroit 12, Michigan • Telephone: TWinbrook 1-3111



DOUBLE-ENVELOPING  
WORM GEARS



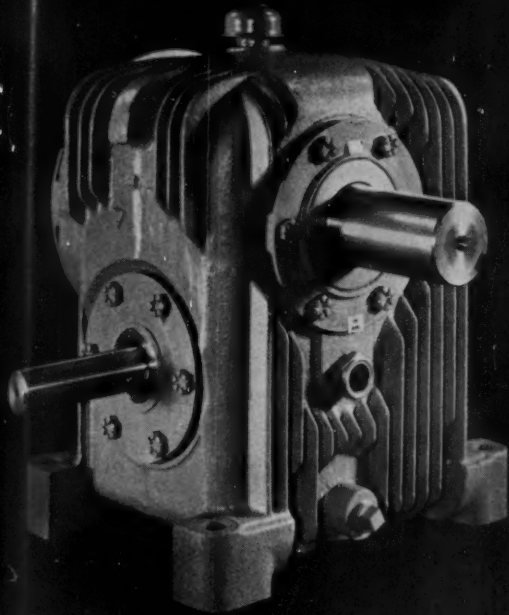
DOUBLE-ENVELOPING WORM  
GEAR SPEED REDUCERS



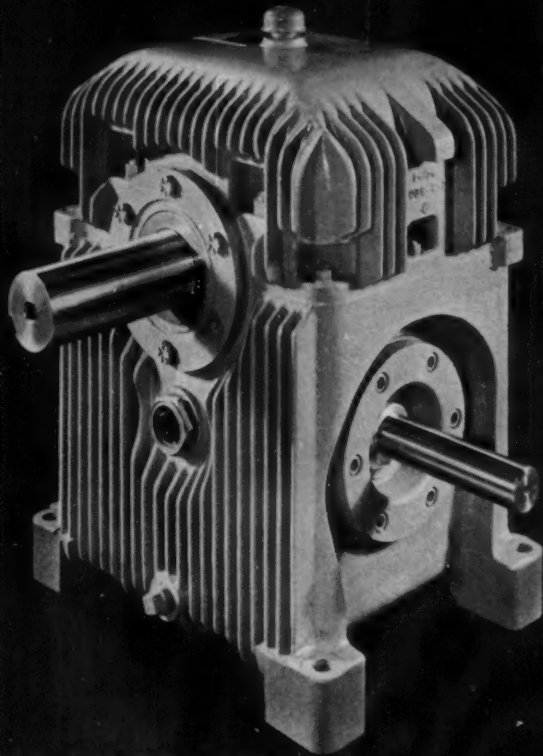
DOUBLE REDUCTION WORM  
GEAR SPEED REDUCERS



DOUBLE-ENVELOPING  
RIGHT ANGLE GEARMOTORS



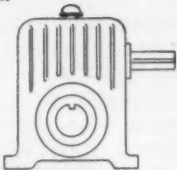
5, 6, 7" center distance



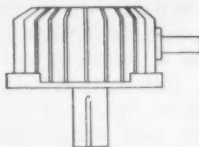
8, 10, 12" center distance

# K-CONE-DRIVE REDUCERS

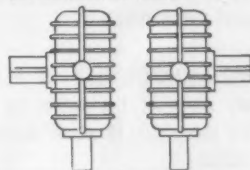
WORM-OVER



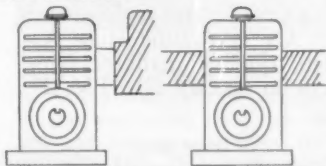
VERTICAL GEARSHAFT



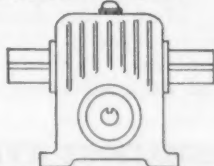
RIGHT- OR LEFT-HAND SHAFT



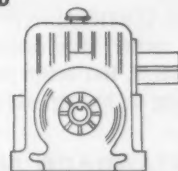
SHAFT MOUNTED



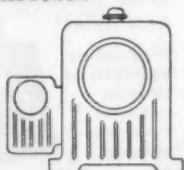
DOUBLE-EXTENDED GEARSHAFT



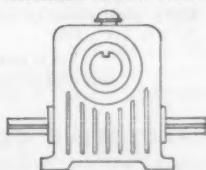
FAN-COOLED



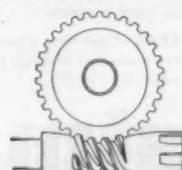
DOUBLE REDUCTION



DOUBLE-EXTENDED WORM SHAFT



GEARSETS & MOUNTINGS



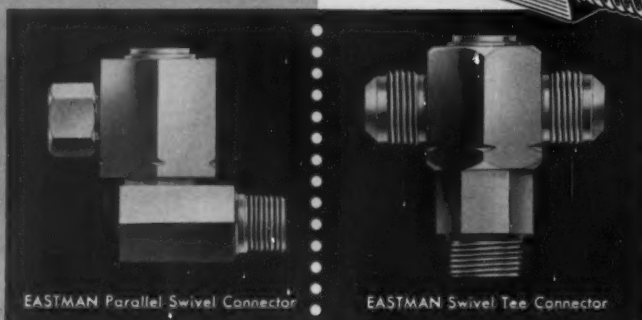




Licensed Under  
Pat. No. 2481404

## AMAZING VERSATILITY AND ADAPTABILITY!

These two adaptations, specified by two of America's largest major equipment manufacturers, reveal the unique adaptability and versatility of EASTMAN'S improved Industrial Swivel Connector.



### **improves SEALING QUALITY**

through use of SIX seals, thereby eliminating failure from grit, dust and other foreign materials.

### **improves SERVICE LIFE**

through new design and engineering, the interior is chrome-hardened with a highly polished mirror finish.

### **improves UNIFORMITY OF FLOW**

at any angle of the swivel by undercutting the shaft to equal diameter of the orifice.

### **improves SERVICEABILITY**

through shorter, more compact housing; saving weight. Hex design permits multiple tapping on housing; easier assembly.

**W**hile the use of EASTMAN'S High Pressure Industrial Swivel Connector eliminated the cause of hose failure due to constant, extreme flexing, it tended to increase the load on the swivel connector.

To improve the performance of the swivel itself, EASTMAN engineers improved its internal design, chrome-hardened its interior surfaces, cadmium plated the shaft and then machined them to a mirror-like finish.

Satisfactory service under the most unfavorable field conditions was insured by increasing sealing rings from four to SIX: 2 leather dust seals, 2 synthetic back-up washers and 2 quad rings of oil-resistant rubber ( $-65^{\circ}$  to  $+250^{\circ}$ ).

Exhaustive tests at 3000 p.s.i., through one million cycles, with the hydraulic fluid saturated with abrasives, dirt and other foreign materials, proved EASTMAN'S Industrial Swivel Connector satisfactory in every respect and did not cause failure of any kind.

That is why America's leading OEM's and replacement buyers specify *complete* EASTMAN Hydraulic Hose Assemblies... for improved design, quality manufacturing and exhaustive testing. It pays to specify EASTMAN.

## STANDARD SIZES AND COMBINATIONS AVAILABLE

**LOW TORQUE**—Freedom from friction, even under high pressure.

**WIDE RANGE**—Operating pressures up to 5000 p.s.i. trouble-free operation through wide temperature range ( $-65^{\circ}$  to  $+250^{\circ}$ ).

**ROTATION**—Full  $360^{\circ}$  for all manifolds.

**SIZES**—Steel, plated for corrosion protection— $\frac{1}{2}''$ ,  $\frac{3}{4}''$ ,  $1''$ ,  $1\frac{1}{4}''$ .

Other sizes available on request.

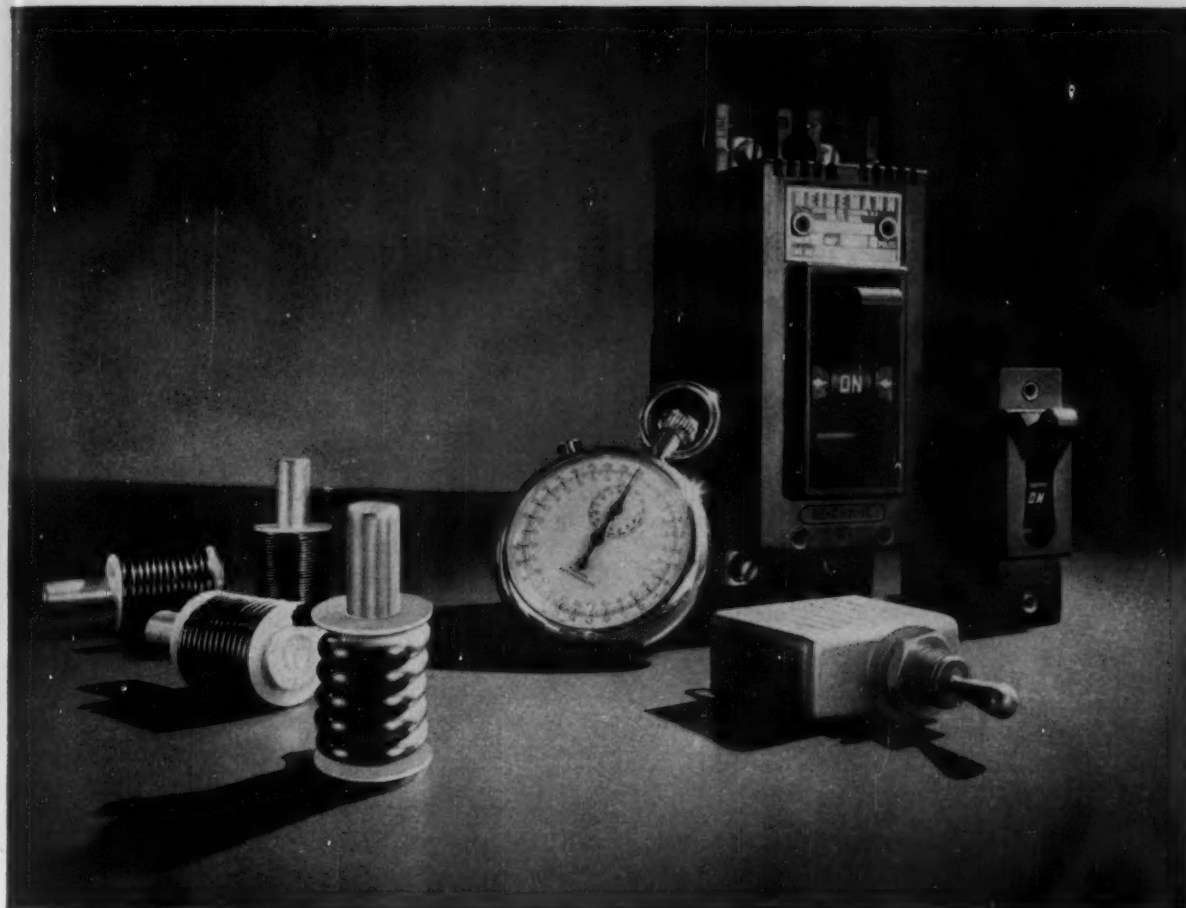
**LOOK INTO  
EASTMAN'S IMPROVED  
SWIVEL CONNECTOR—  
WRITE TODAY!**

Please send me  
Bulletins 100 and  
200 on low,  
medium and  
high pressure  
assemblies.

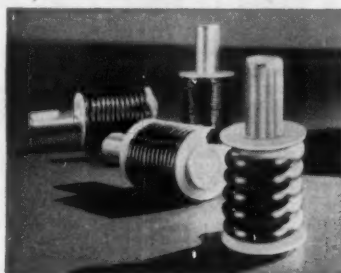


# Eastman

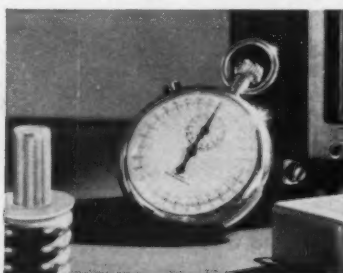
**MANUFACTURING COMPANY**  
Dept. MD-8, MANITOWOC, WISCONSIN



## NEED 'TIGHT-SPEC' OVERCURRENT PROTECTION? HEINEMANN WILL CUSTOM-MAKE A BREAKER FOR YOU!



**Precise current ratings, odd or fractional.** The number of wire turns of the breaker overload coil determines the current rating. We can wind any one you want between 0.010 and 100 amps (200 on one model) —even way-out ratings like 4.5 or 17.8 or 73 amps.



**Choice of time delays.** Long, medium, short or instantaneous trip — you can pick the time-delay/percent overload curve which best matches the operating requirements of the protected equipment. The delayed response prevents nuisance tripping on safely tolerable overloads.



**Diversity of models.** We have them from sub-miniature size on up. Most are available in single-, two- and three-pole constructions, and most can be furnished with a variety of mounting arrangements and terminal hardware styles. Special environmental treatments available, too.

No other overcurrent-protection device quite equals the Heinemann circuit breaker in adaptability to specialized, close-tolerance protective functions. If you'd like to see for yourself, send for a copy of the Circuit Breaker Engineering Guide, Bulletin 201.

**HEINEMANN ELECTRIC COMPANY**



**172 PLUM ST., TRENTON 2, N.J.**

S.A.-2127

## New Aluminum Precote Process Insures Positive Gasket Performance

**Exclusive Victor Aluminum Precote speeds heat transfer . . . provides higher temperature resistance . . . compensates for irregularities of mating surfaces . . . eliminates need of supplementary gasket cement**

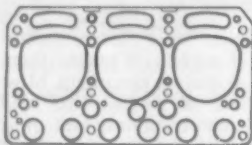
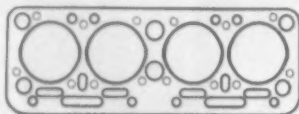
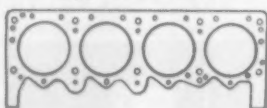
This newly developed Aluminum Precote provides simplified gasket installation and insures positive performance on high-temperature engine applications.

Deficiencies in earlier gaskets of this type have been completely eliminated by a new and thoroughly tested aluminum pigmented organic coating, and by refinement of the application method.

### New Advantages

- The new processing method permits application of coating to finished gaskets, ready for shipment when coated, thus eliminating possible handling damage.
- Improved coating formula and new application method permit a heavier and completely uniform film on both gasket faces, in controlled thickness from .00075 to .0015 in.
- Controlled baking of coated gaskets at 400 deg. F. gives notably increased resistance to high working temperatures. Precote adhesion to gasket surfaces is improved.
- Resistance to gasket corrosion on contact with antifreeze and coolants is greater—with reduced possibility of blow-by between combustion chamber openings of gaskets.
- The new, higher-heat-converted Aluminum Precote remains soft enough to permit conformance of gasket to mating surface irregularities of engine head, block, flange faces, etc. At the same time new Aluminum Precote has improved properties for easy removal of gaskets.

### Available Gasket Types and Uses

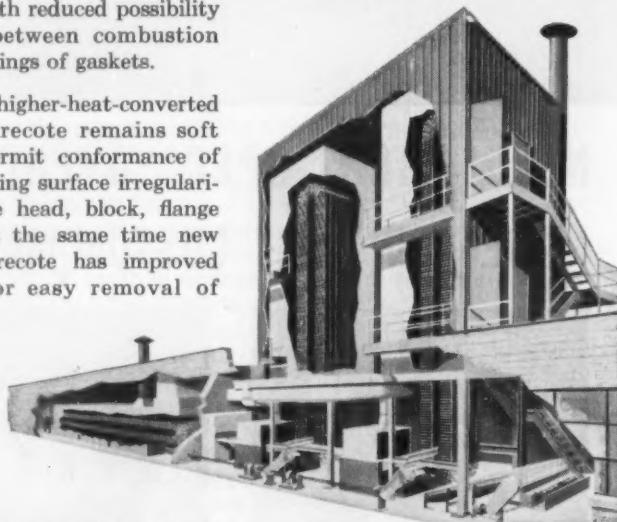


Improved Aluminum Precote is performing successfully on beaded steel, metal-and-asbestos, metal core, and other gaskets suitable for engine head, manifold, transmission, and similar high-temperature, heavy-duty installations.

ice—or your inquiry for complete technical data and prices—involves no obligation. Handle through your Victor Field Engineer or direct with the factory. See address below.

### New and Improved Facilities Allow High-Capacity Production

Three stories tall, and based on automated conveyor system operation, this Victor installation chemically prepares incoming gaskets, applies and bakes-on Aluminum Precote in



For your test purposes Victor will apply—at no charge—this new Aluminum Precote to two or more pieces on any Victor head gasket you are currently using. This serv-

**SAMPLES  
FREE...  
ON YOUR  
OWN  
GASKETS**

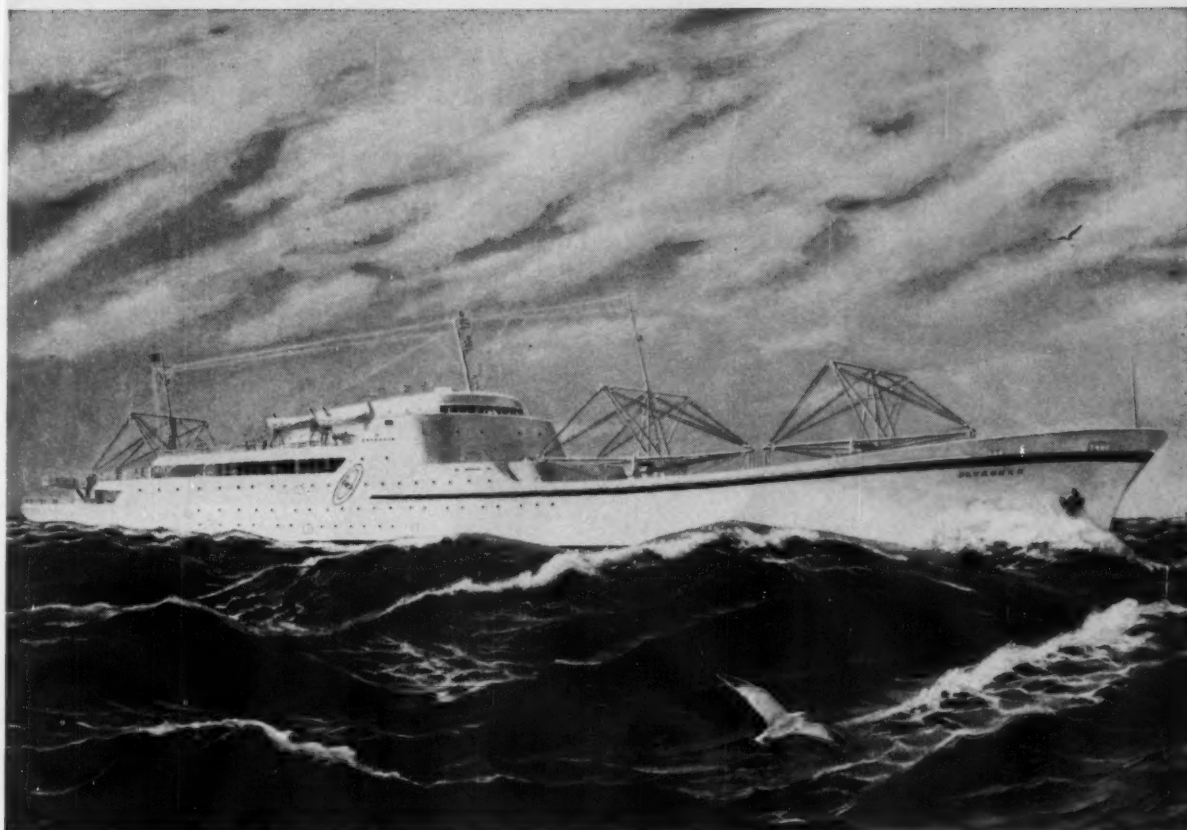
one continuous pass. This exclusive system improves the product and gives Victor much-enlarged production capacity.

Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ontario.

## VICTOR GASKETS

World's leader in gasket design and development  
for automotive and industrial application





**N.S. Savannah**, built by New York Shipbuilding Corporation, can sail for three years on 138 pounds of nuclear fuel. A conventional ship would burn 80,000 tons of oil.

## 'round the world 13 times with fuel to spare ...the first nuclear-powered merchant ship

This is the Nuclear Ship Savannah, first of her kind. Capable of sailing over 350,000 nautical miles without re-fueling, she points the way to a new era in transport and travel at sea.

Her uranium oxide fuel is packaged in tubes of Nickel Stainless Steel...more than 5,000 of them. The fuel-element cans that hold these tubes are also made of this strong, corrosion-resisting metal.

Wherever you look, inside the reactor, almost everything is Nickel Stainless Steel. 200,000 pounds of it are used in the reactor area: for the lining of the reactor vessel, for the coolant pumps and tubing that circulate corrosive "hungry" water, and for the control rods inside the atomic pile.

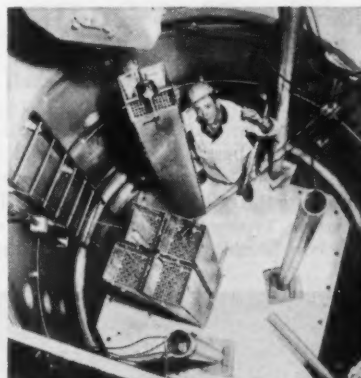
At the design stage, engineers anticipated the high operating pressures—

1,750 pounds per square inch—and temperatures up to 508°F. They selected Nickel Stainless Steels to provide the strength and resistance to heat and corrosion needed to withstand these rigorous conditions.

So the next time you need more from a metal, remember the N.S. Savannah. Nickel Stainless Steel, or another Nickel alloy, may be the solution to your problem, too.

A note to Inco will bring you "First Steps Towards Solving Specific Corrosion Problems" and "High Temperature Worksheet"...simplified forms you can use to describe your metal problem. Perhaps our technical staff has information that will help you find the solution.

The International Nickel Company, Inc.  
67 Wall Street New York 5, N.Y.



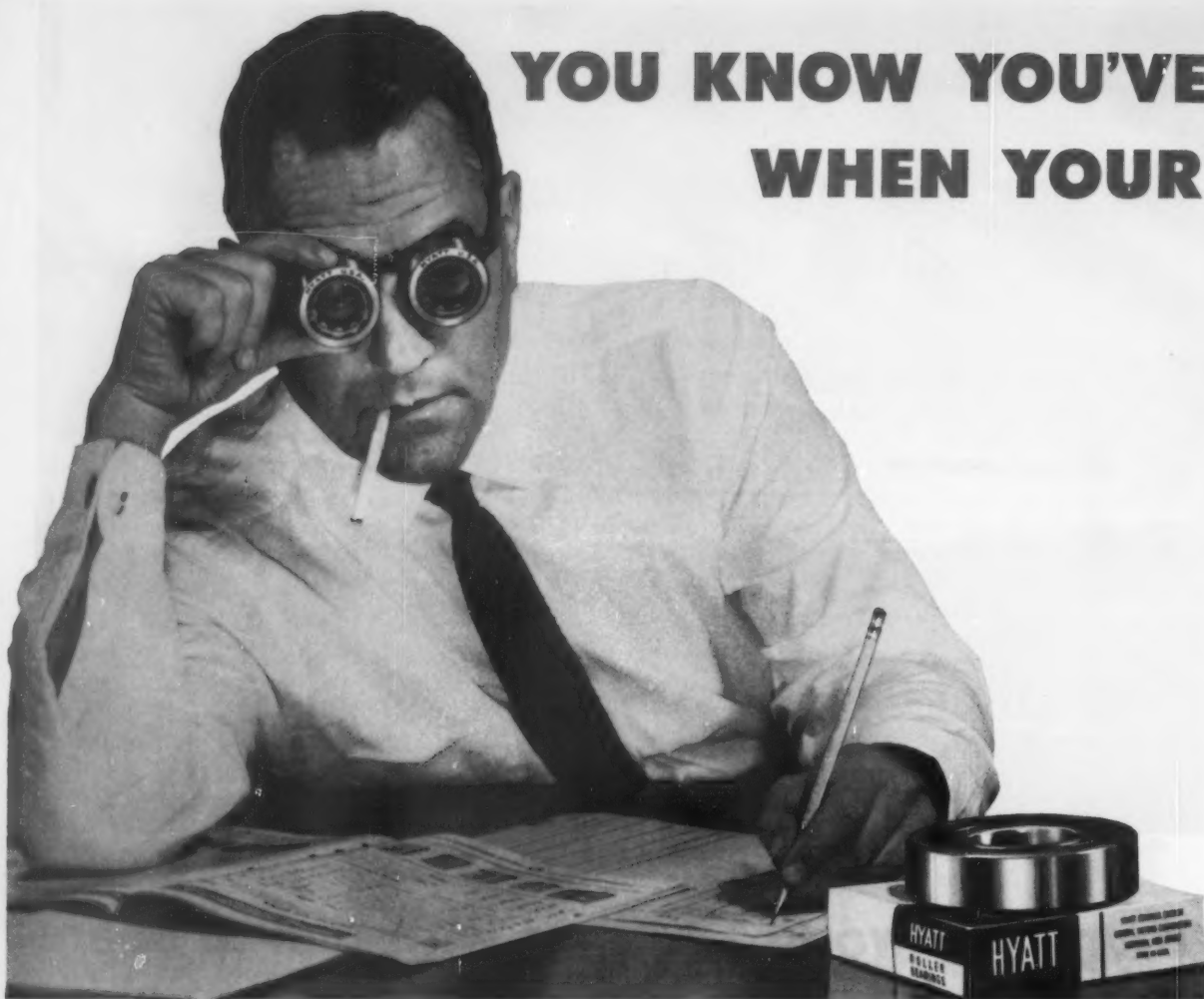
Inside the reactor nearly everything you see is Nickel Stainless Steel to withstand corrosion, high temperatures and pressures that hit 1,750 psi. Reactor built by Babcock & Wilcox Co., Barberton, Ohio.

# INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER



# YOU KNOW YOU'VE WHEN YOUR

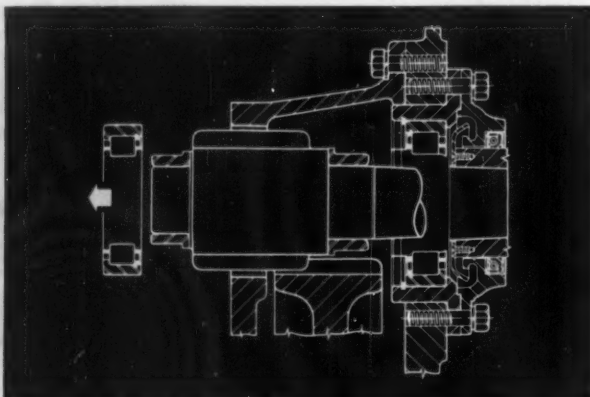
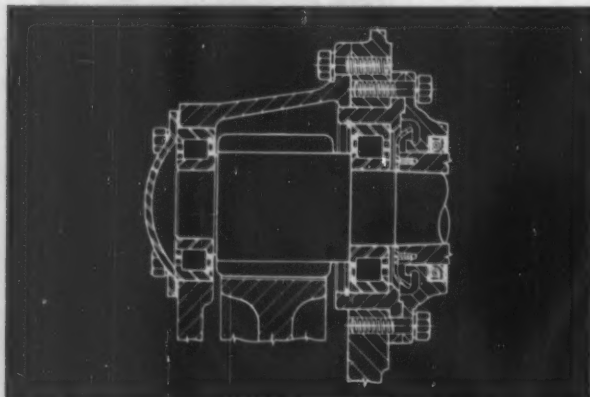


## SIMPLIFY AND SAVE

A second look at the very same shaft shows how easy it is to "design in" a Hyatt bearing. It requires no costly end clamps, threads, nuts, screws or washers. That's because Hyatt Hy-Roll bearings can be affixed to the shaft with a heavy press fit. Rest assured, they'll never come loose because Hyatt Hy-Roll races are made from case-hardened, carburizing type steel. The hard outer case and tough ductile core permit heavier press fits without fear of cracking.

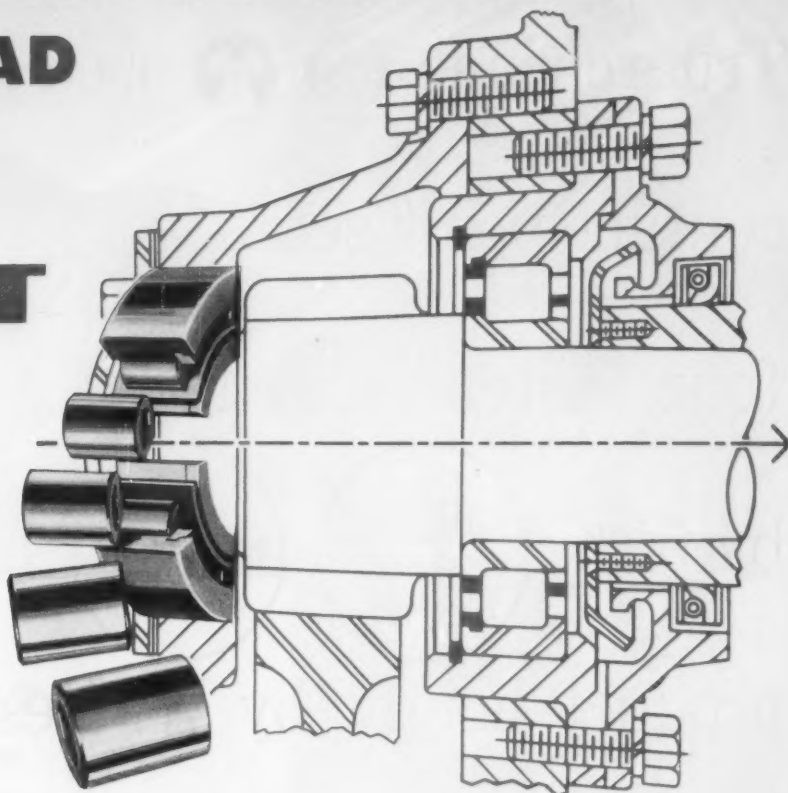
## EXPEDITE ASSEMBLY

When a product is assembled, you can see why Hyatt makes all separable races interchangeable within the same part number. For it allows you to press the inner race on the shaft at one work station, then later fit it into any of the mating assemblies already installed in the housing. You don't have to worry about matched assemblies because Hyatt has made selective fitting unnecessary. Think of the time it saves!



# PUT THE SHAFT IN ITS PLACE "SPECS" READ

# HYATT



## DO BOTH JOBS AT ONCE

Remember how versatile Hyatt Roller Bearings can be. Primarily, they're designed for the heaviest radial loads. But, with shouldered races, they'll also accommodate a considerable amount of thrust load . . . enough to provide adequate shaft location.

Here, for example, is a spur gear drive pinion on an opposed pair of R-YS type Hyatt Hy-Roll Bearings. Shoulders on the inner and outer races restrict lateral movement without sacrificing any of the high load carrying capacity inherent to cylindrical roller bearings. Thus, Hyatt gives you a bearing combination that combines high radial load carrying capacity with convenient shaft location.

You're assured smooth, trouble-free performance the minute you specify Hyatt Hy-Roll Bearings. For Hyatt quality is constantly checked and electronically controlled to insure that the last Hyatt Hy-Roll is every bit as accurate as the first.

Hyatt produces 10 major bearing types—four have

separable inner races



—four non-separable



—and two have separable outer races.



The separable race can be omitted and rollers operated directly on the shaft or in the housing bore, in instances where the shaft or housing bore can be suitably hardened and ground.




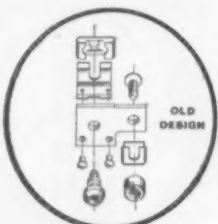
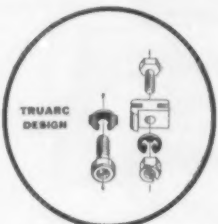
For full details on selection and application of these bearings see Hyatt Catalog 150 or call your nearest Hyatt Sales Engineer.

Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey

# HYATT

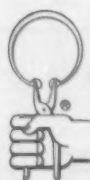
## HY-ROLL BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR  RELIABILITY

Truarc rings   used in redesign of contact point sets  eliminated four fasteners, reduced assembly time by 50%   and decreased product height by  $\frac{1}{4}$ ". Result: SHURHIT PRODUCTS, INC. saved \$60 per 1000 units.

## A DESIGN PROPOSITION:

What would the impact of Truarc Retaining Rings be on your product? They save materials and labor...simplify design and assembly...and lower the installed cost of hundreds of products. Catalog RR10-58 shows how *other* designers use rings on more than 70 different products. Get your copy today. Your nearest **Authorized Truarc Distributor** is as close as your telephone. For immediate action, check your Classified Telephone Directory under: "Rings, Retaining."



**WALDES**

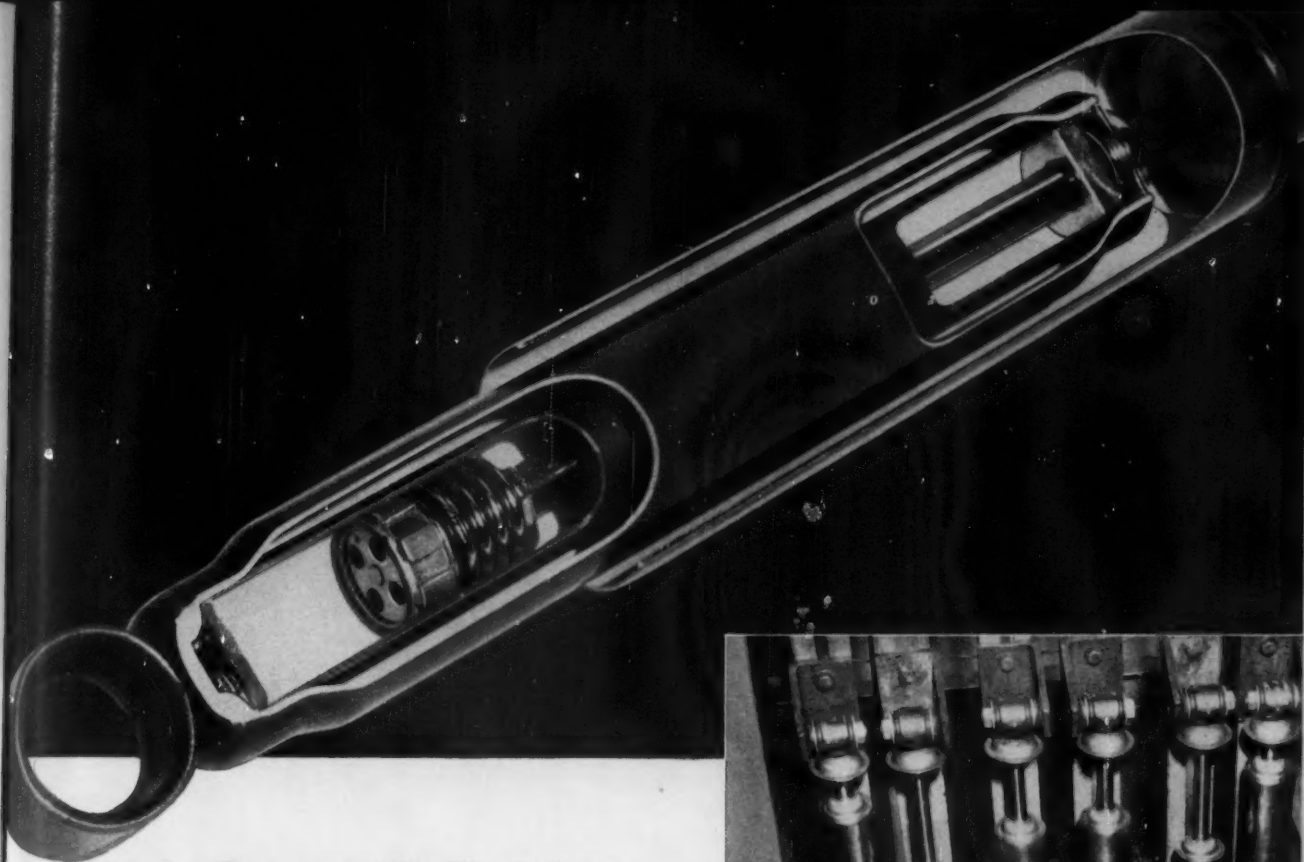
**TRUARC<sup>®</sup> RETAINING RINGS**

WALDES KOHINOOR, INC., 47-16 Austel Place, Long Island City 1, N. Y.

O.1A

9 OUT OF 10 PRODUCTS CAN BE IMPROVED WITH TRUARC RETAINING RINGS

© 1960 WALDES KOHINOOR, INC.

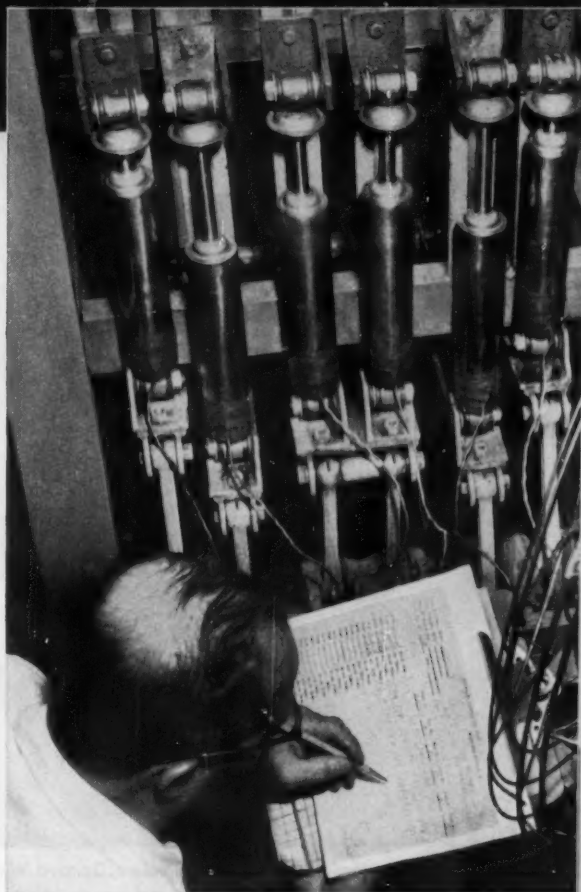


## Jal-Smooth Tubing Solves Piston Ring Problem

**The Problem:** You have a patented shock absorber design which cuts production costs, but it requires a *rubber* piston ring. **The Solution:** Use Jal-Smooth, J&L's mandrel-drawn Electricweld tubing, with superior special smooth I.D. finish. **Example:** The Gabriel Company, Cleveland, Ohio.

"We use Jal-Smooth tubing because of its bore smoothness, its fine uniformity, and the substantial cost reduction its use permits," says R. H. Whisler, chief engineer for the Gabriel Company. "Our average acceptance rate is 99.5%, quite impressive since we produce over 1,000,000 pieces in a typical month."

A rubber O-ring, instead of the piston itself, makes contact with the walls of the innermost cylinder in Gabriel shock absorbers. This inner cylinder is a key portion of the standard Gabriel shock absorbers. Under road conditions, piston movement is abrupt, often violent. Any roughness or lack of uniformity in the Jal-Smooth tubing would cause trouble, and customer complaints. The consistent quality of Jal-Smooth tubing fully satisfies Gabriel's design needs. To see for yourself the quality of Jal-Smooth mandrel-drawn tubing, call your J&L representative or write direct to:



Test machine shown here simulates road conditions. Inner cylinders of completed shock absorbers must endure more than 2,000,000 cycles during testing.

Cutaway drawing shows standard Gabriel shock absorber. Inner cylinder is fabricated from 15-foot lengths of mandrel-drawn Jal-Smooth tubing. Intermediate tubing is also made by J&L. Cylinder smoothness and uniformity permit use of patented rubber-ringed piston.

This Steelmark identifies products made of steel. Place this mark on your products. And—look for it when you buy.



**Jones & Laughlin Steel Corporation**

**STEEL** ELECTRICWELD TUBE DIVISION • 3 GATEWAY CENTER, PITTSBURGH 30, PA.

Circle 465 on Page 19



# "Now get immediate of complete line of



A. T. Gallagher, Manufacturing Superintendent, Delroyd Worm Gearing.

"Here's a shot of our Delroyd Verso worm gear — one of hundreds being boxed and made ready for shipment. Unlike most speed reducers, this Verso unit can be mounted in any position — horizontal, vertical, upside down. • "This is but one model in a complete line of Delroyd worm gear reducers — with the widest range of horsepowers and sizes in the industry."\*

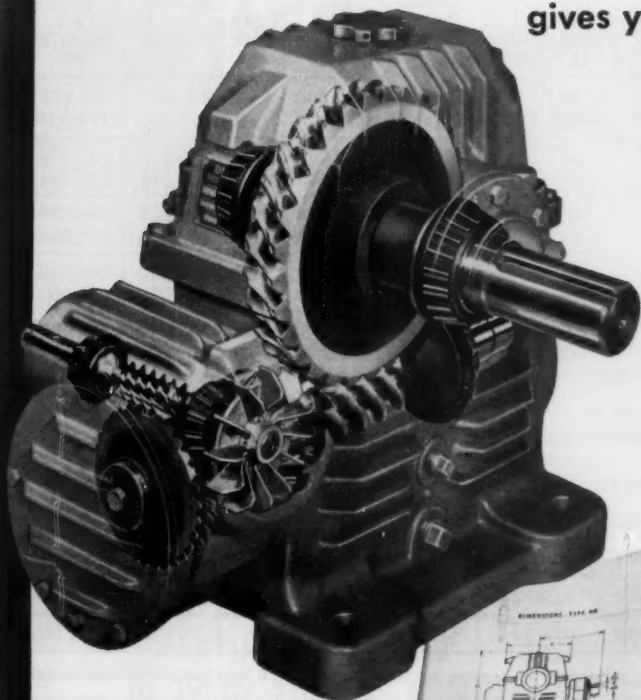
\* $1\frac{1}{8}$ " center distance, fractional horsepowers — to 12" center distance, 152 horsepower. Reducers to 36" center distance with horsepower capacities to 700 are supplied as standard. Larger units to meet any requirement can be supplied on special orders.

delivery

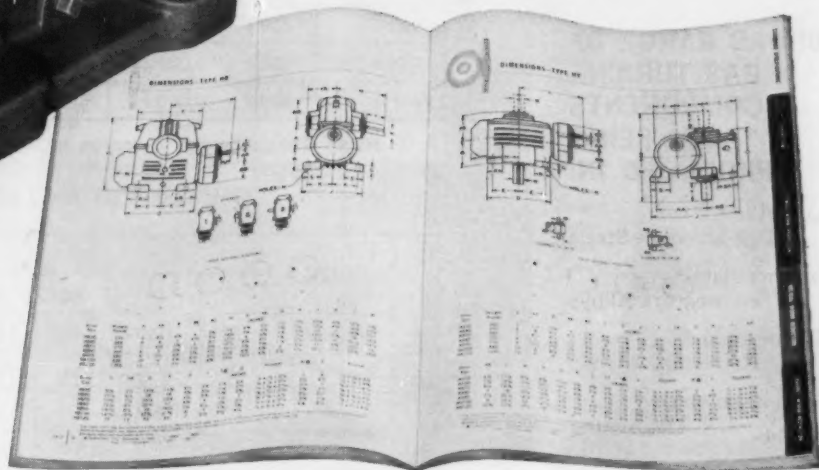
# DELROYD worm gearing..."

**DELROYD worm gearing**  
gives you these superior design features:

- Exclusive involute helicoid thread form for highest load capacities
- Centrifugally cast bronze gear for increased mechanical ratings
- Fan cooled finned housings for higher thermal ratings
- Lower weight per horsepower
- More horsepower per dollar



**NEW**  
full color  
84-page  
Delroyd  
Catalog:



Now available — the worm gear industry's newest, most complete catalog. Contains all basic design and application data, selection charts, ratings and service factors — plus illustrations in full color. For your free copy, write on your company letterhead to: Delroyd Worm Gearing, De Laval Steam Turbine Company, Trenton, New Jersey.



**DE LAVAL**

**STEAM TURBINE COMPANY**

858 NOTTINGHAM WAY, TRENTON 2, N. J.

DL-216

# Wyman-Gordon makes a major contribution to the gas turbine industry

## Now parts are being forged in the U.S.



Nickel-base  
high-temperature alloy  
45" diameter  
520 pounds

### BROAD RANGE OF GAS TURBINE COMPONENTS ALSO BEING PRODUCED IN:

- Low-Alloy,  
High-Strength Steels
- Intermediate-  
Temperature Alloys
- Titanium and  
Refractory Metals
- Aluminum and  
Magnesium



High-strength steel  
19" diameter  
143 pounds

### PHYSICAL PROPERTIES

TENSILE AND YIELD STRENGTHS	ALLOY*	TEST TEMPERATURE °F.	HEAT TREAT	GUARANTEED MINIMUM			TYPICAL VALUES		
				ULTIMATE TENSILE STRENGTH PSI	0.2% YIELD STRENGTH PSI	ELONGATION %	ULTIMATE TENSILE STRENGTH PSI	0.2% YIELD STRENGTH PSI	ELONGATION %
	Waspaloy	RT	A	175,000	120,000	15.0	194,000	136,000	24.0
		1000	A	162,000	112,000	13.0	175,000	124,000	23.0
	René 41	RT	B	180,000	132,000	12.0	200,000	150,000	15.0
		1400	B	135,000	115,000	13.0	145,000	125,000	18.0
	Astroloy	RT	C	190,000	138,000	10.0	205,000	152,000	12.0
		1400	C	150,000	122,000	12.0	160,000	132,000	15.0
	U-500	RT	D	175,000	120,000	10.0	195,000	135,000	12.0
		1400	D	125,000	105,000	12.0	140,000	120,000	15.0
	M-252	RT	B	170,000	115,000	15.0	185,000	125,000	20.0
		1000	B	160,000	105,000	15.0	165,000	115,000	22.0

STRESS RUPTURE	ALLOY*	TEMPERATURE STRESS	GUARANTEED MINIMUM		TYPICAL VALUES	
	Waspaloy	1350°F.—70,000 psi	70 hours—6% Elongation		130 hours—16% Elongation	
	René 41	1350°F.—85,000 psi	30 hours—8% Elongation		60 hours—15% Elongation	
	Astroloy	1800°F.—20,000 psi	20 hours—7% Elongation		35 hours—12% Elongation	
	Udimet 500	1650°F.—25,000 psi	30 hours—6% Elongation		55 hours—12% Elongation	
	M-252	1500°F.—40,000 psi	30 hours—8% Elongation		55 hours—16% Elongation	

NOTE: The guaranteed minimums are based upon radial and tangential test locations.

### COMPOSITION AND HEAT TREATMENT

CHEMISTRY	ALLOY*	ELEMENTS						
		C	Cr	Mn	Co	Ti	Al	Ni
	Waspaloy	.08	19.0	4.3	13.5	3.0	1.4	.004
	René 41	.08	19.0	10.0	11.0	3.1	1.6	.004
	Astroloy	.05	15.0	5.0	15.0	3.5	4.3	.030
	Udimet 500	.07	18.5	5.0	18.3	3.0	3.0	.003
	M-252	.15	20.0	10.0	10.0	3.0	1.3	.002

HEAT TREATMENT	A.	1850°F.—4 hours—OQ; 1550°F.—2 hours—AC; 1400°F.—16 hours—AC
	B.	1950°F.—4 hours—AC; 1400°F.—16 hours—AC
	C.	2100°F.—½ hour—AC; 1400°F.—16 hours—AC
	D.	1975°F.—4 hours—AC; 1500°F.—24 hours—AC; 1400°F.—16 hours—AC

NOTE: Refer to appropriate heat treat code in Tensile & Yield Strength table.

\*Waspaloy: Pratt & Whitney Aircraft Corp.; René 41, Astroloy and M-252: General Electric Company; Udimet 500: Metals Division, Kelsey-Hayes Company.



# ... contribution to gas turbine progress ... ... these new Superalloys with Guaranteed

permits designing to higher operating stresses  
... increased efficiency ... greater component  
reliability for every gas turbine application

Rapid progress in developing the gas turbine has materially extended application of this prime power source to areas other than aircraft. Significant contributions in forging techniques and metallurgical advancements by Wyman-Gordon have in part made this possible.

Now designers are free to explore new frontiers of turbine performance unhampered by former material limitations. The high temperature alloys shown here exhibit outstanding tensile and stress rupture strengths in elevated temperature environments. These alloys have been forged into discs, shafts, rings, blades and vanes on a production scale.

Wyman-Gordon offers these alloys to *guaranteed minimum properties* for such vital components. This is made possible by the broad experience in forging parts from all difficult-to-work materials, including a complete range of low-alloy, high-strength steels; intermediate-temperature alloys; light metals; titanium and the refractory materials.

Our metallurgists and forging engineers are prepared to counsel on turbine components ... evaluating material requirements and forging of existing designs and development parts. For assistance or additional information on Superalloy forgings, write—Product Manager, Turbine Applications, Wyman-Gordon Company, Worcester, Massachusetts.

## MEETING DESIGNERS' NEEDS IN EVERY TURBINE APPLICATION

- Aircraft and Missile
- Nuclear Power and Propulsion
- Rail and Highway Transport
- Power Generation
- Air Supply and Pumping
- Pipeline Boosting
- Auxiliary Service
- Automotive
- Marine Propulsion
- Stationary Power



Titanium  
15½" length

FORGED

WASPALOY

RENÉ 41

ASTROLOY

UDIMET 500

M-252

Titanium  
24½" diameter  
191 pounds

# WYMAN - GORDON

## FORGINGS

of Aluminum Magnesium Steel Titanium ... and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS

WORCESTER MASSACHUSETTS

DETROIT MICHIGAN

GRAFTON MASSACHUSETTS

LOS ANGELES CALIFORNIA

PALO ALTO CALIFORNIA

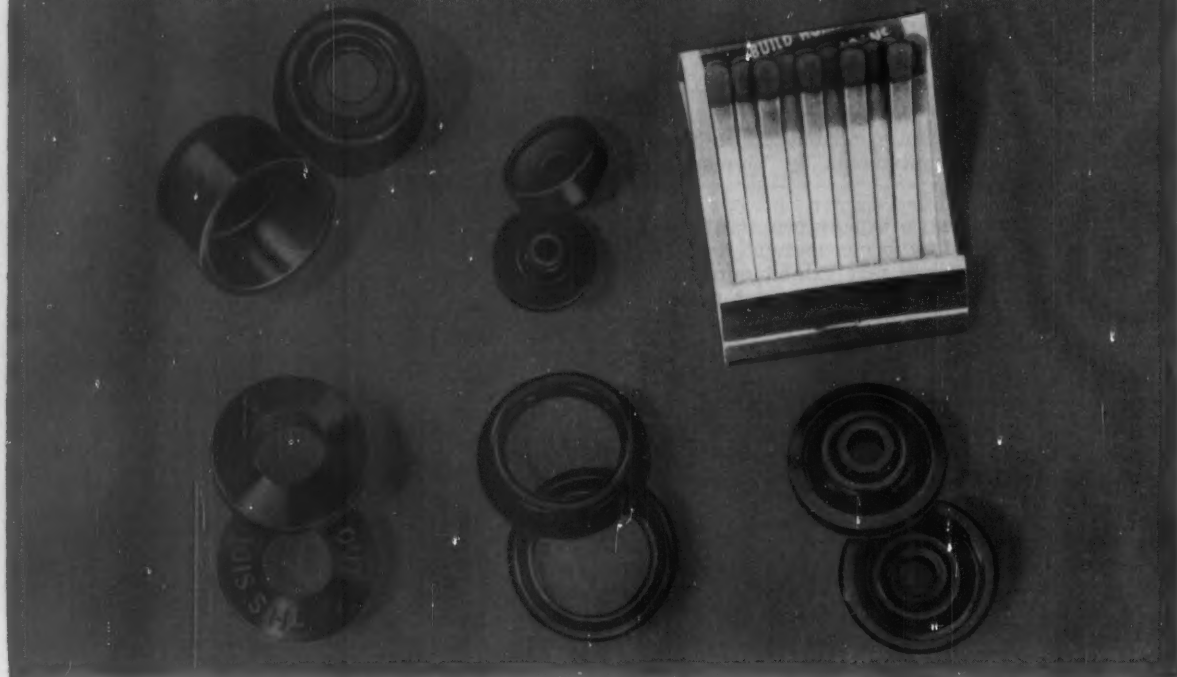
FORT WORTH TEXAS

Circle 466 on Page 19



# OHIO RUBBER

"CUSTOMEERED COMPONENTS BASIC TO INDUSTRY"



Wide range of parts includes (top, left to right): valve stem deflector, condenser seal, (bottom) seal piston rod packing, universal joint seal, and oil seal. These vary in dimensions up to 1½" in diameter and 1" in thickness.

## NEW! Precision rubber parts continuously molded in high volume... at lower cost

Precise tolerances within  $\pm 0.003$  in. are now possible in large volume production of custom-molded rubber component parts. Ohio Rubber's new high-speed, continuous molding process produces such parts at rates of up to 200,000 pieces per day.

**Greater precision**, which results in important savings on finishing costs, is assured through use of single-cavity, self-registering molds. They permit accurate, uniform application of pressure to minimize flash—maintain consistent tolerances for all dimensions. Uniform material thickness is equally assured by a plasticizing mill, which as an integrated part of the process directs uniform charges to each mold.

**Direct feeding**, from the mill to the mold wheel, eliminates the conventional intermediate extrusion step and further

insures part uniformity and quality consistent with specifications. The continuous process permits *precise* control of time and temperature for each part.

**Large volume production** results in substantial cost savings for small, precision parts requiring tolerances obtainable by other precision molding processes. For parts formed by less precise, conventional methods, performance can be improved through greater accuracy—and without prohibitive increase in cost.

Quantity requirements involving 500,000 or more parts annually are

recommended for most advantageous use of the new process. Since two similar parts of different size can be produced simultaneously by alternating the molds on the molding wheel, lower production runs which might not be economical can be combined with a separate order.

**Complete information** on this revolutionary new process is available in bulletin form. Send for your free copy today. At the same time, be sure to inquire about Ohio Rubber's complete component "Customengineering" service—molding, extruding, and bonding-to-metal. Just mention ORCO Bulletin 715.

DE-260



**THE OHIO RUBBER COMPANY**

General Office • WILLOUGHBY, OHIO • Whitehall 2-0500

A DIVISION OF THE EAGLE PITCHER COMPANY



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"FADE-OUT" PAPER  
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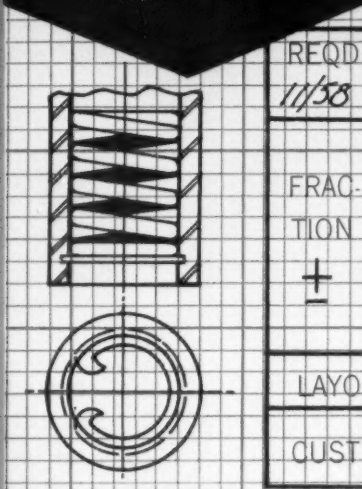
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13

PART NO		DESCRIPTION	
REQD	6304	R.M. Spring	
11/58	ODD DASH NUMBER SHOWN NEXT HIGHER		
DIMENSIONS IN INCHES		DATE 6/19/58	
FRAC- TION	TOLERANCES	ANGLE	DFTMN
±	.X .XX .XXX ± ± ± 03 .010	±	JN
LAYOUT See file 166-A		CHK B9C	
CUSTOMERS SEE DWG 33644		MATL Spec. 104	
		STRESS Std	
		SUPV L.M.	
		PROD H. J. Inc.	
		APPD 7/2/58	

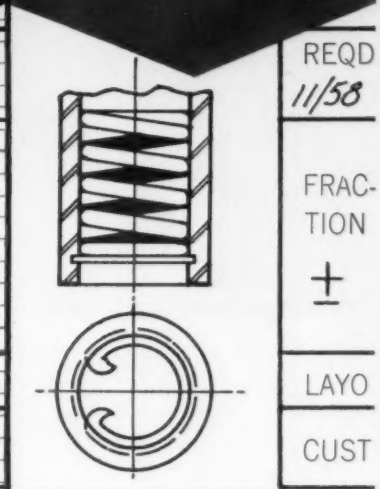
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MD-258

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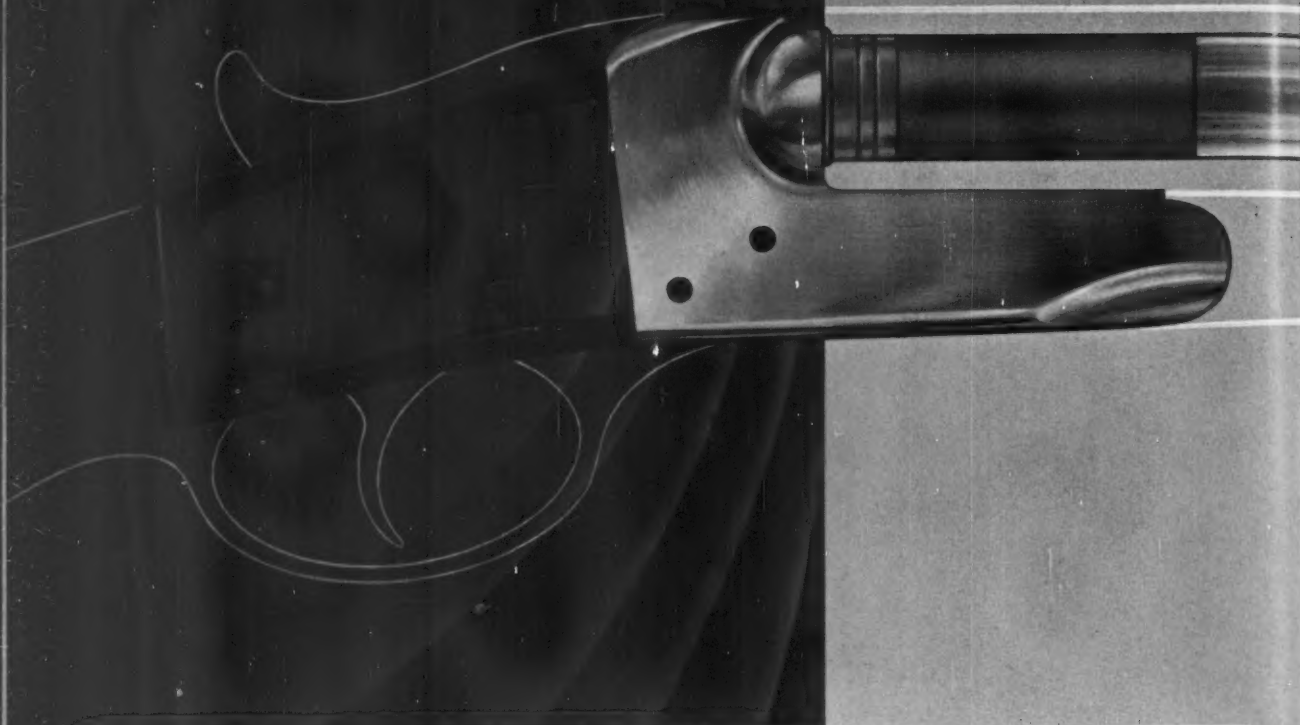
☐ Have your representative call at my office to discuss special applications for my particular needs.

Name \_\_\_\_\_

Firm \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_



Pressure on the face of this Malleable iron receiver approaches 5 tons per square inch each time this 12 gauge shotgun is fired.

## For Really Tough Parts...Use **Malleable**

With high powered charges being fired just inches from your face, you don't want parts that can't take it. That's why so many weapon parts are made of tough Malleable iron castings.

Tremendous resistance to impact, fatigue, deflection, and wear also makes Malleable castings favorites among manufacturers of mining and construction equipment, heavy-duty tools, and other products that require extra tough components.

Have you investigated how Malleable castings will improve your product's performance and cut costs at the same time? If not, send drawings or outline of your requirements to a nearby Malleable castings producer who displays this symbol —



For detailed information on "Toughness", contact any of the progressive companies listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.



# Malleable Assures Toughness and Dependability for Torsion Arms

Torsion arms are the vital link between the violent motion of the wheels and the resisting force of torsion bars. Tough, dependable Malleable iron castings are used for torsion arms by every manufacturer of vehicles that employ torsion bar suspension systems. Malleable castings take this kind of punishment without failure.

First, Malleable's modulus of elasticity provides the rigidity necessary to resist deflection under heavy loads. Second, Malleable castings' high ratio of yield to tensile guarantees plenty of reserve strength, even for torsion arms on trucks used continuously for off-the-road service.

## Tensile Properties—A.S.T.M. Minimum Specifications Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.
<b>Standard</b>			
35018	53,000	35,000	18
32510	50,000	32,500	10
<b>Pearlitic</b>			
45010	65,000	45,000	10
45007	68,000	45,000	7
48004	70,000	48,000	4
50007	75,000	50,000	7
53004	80,000	53,000	4
60003	80,000	60,000	3
80002	100,000	80,000	2

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

## Other Mechanical Properties Standard and Pearlitic Malleable Irons

	Standard	Pearlitic
Modulus of Elasticity in Tension, p.s.i.	25,000,000	25,500,000—28,000,000
Ratio of Fatigue Strength to Tensile Strength	0.54	0.40—0.50
Shear Strength—% of Tensile Strength	80—90%	70—85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000



In addition to their proven toughness and stamina, Malleable castings are outstanding for manufacturing economy. Modern casting methods produce parts so close to finished shape that surplus metal is reduced to the minimum. Malleable saves time and tools in machining because no material of comparable properties machines so easily and quickly.

### FREE ENGINEERING GUIDE

A condensed synopsis of engineering data plus case histories that may suggest ways for you to improve your products is available from any member of the Malleable Castings Council, or from the Council's offices, Union Commerce Building, Cleveland 14, Ohio. Just ask for Data Unit No. 105, "Toughness."



## For Quality and Economy... Use

## MALLEABLE

### For Service In Your Area Contact...

#### CONNECTICUT

Connecticut Malleable Castings Co., New Haven 6  
Eastern Malleable Iron Co., Naugatuck  
New Haven Malleable Iron Co., New Haven 4

#### DELAWARE

Eastern Malleable Iron Co., Wilmington 99

#### ILLINOIS

Central Fdry. Div., Gen. Motors, Danville  
Chicago Malleable Castings Co., Chicago 43  
Moline Malleable Iron Co., St. Charles  
National Malleable and Steel Castings Co., Cicero 50  
Peoria Malleable Castings Co., Peoria 1  
Wagner Castings Company, Decatur

#### INDIANA

Albion Malleable Iron Company,  
Muncie Division, Muncie  
Link-Belt Company, Indianapolis 6  
National Malleable and Steel Castings Co., Indianapolis 22

#### IOWA

Iowa Malleable Iron Co., Fairfield

#### MASSACHUSETTS

Belcher Malleable Iron Co., Easton

#### MICHIGAN

Albion Malleable Iron Co., Albion  
Auto Specialties Mfg. Co., Saint Joseph  
Cadillac Malleable Iron Co., Cadillac  
Central Fdry. Div., Gen. Motors, Saginaw

#### MINNESOTA

Northern Malleable Iron Co., St. Paul 6

#### MISSISSIPPI

Mississippi Malleable Iron Co., Meridian

#### NEW HAMPSHIRE

Laconia Malleable Iron Co., Laconia

#### NEW YORK

Acme Steel & Malleable Iron Works, Buffalo 7  
Frazer & Jones Company Division  
Eastern Malleable Iron Co., Solvay  
Oriskany Malleable Iron Co., Inc., Oriskany  
Westmoreland Malleable Iron Co., Westmoreland

#### OHIO

American Malleable Castings Co., Marion  
Central Fdry. Div., Gen. Motors, Defiance  
Dayton Malleable Iron Co., Ironton Div., Ironton

Dayton Malleable Iron Co., Ohio Malleable Div., Columbus 16  
Maumee Malleable Castings Co., Toledo 5  
National Malleable and Steel Castings Co., Cleveland 6

#### PENNSYLVANIA

Buck Iron Company, Inc., Philadelphia 22  
Erie Malleable Iron Co., Erie  
Lancaster Malleable Castings Co., Lancaster  
Lehigh Foundries Company, Easton  
Meadville Malleable Iron Co., Meadville  
Pennsylvania Malleable Iron Corp., Lancaster

#### TEXAS

Texas Foundries, Inc., Lufkin

#### WEST VIRGINIA

West Virginia Malleable Iron Co., Point Pleasant

#### WISCONSIN

Belle City Malleable Iron Co., Racine  
Chain Belt Company, Milwaukee 1  
Federal Malleable Company, Inc., West Allis 14  
Kirsh Foundry Inc., Beaver Dam  
Lakeside Malleable Castings Co., Racine  
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

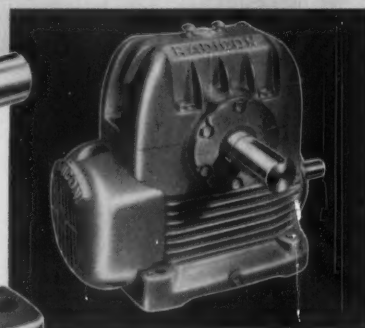




## FOOTE BROS. introduces a **FAN-COOLED**



- ▶ High load carrying capacity
- ▶ Super-efficient 2-way cooling for higher thermal ratings
- ▶ Unlimited mounting positions
- ▶ Automatic and positive lubrication
- ▶ **IN STOCK** for immediate delivery



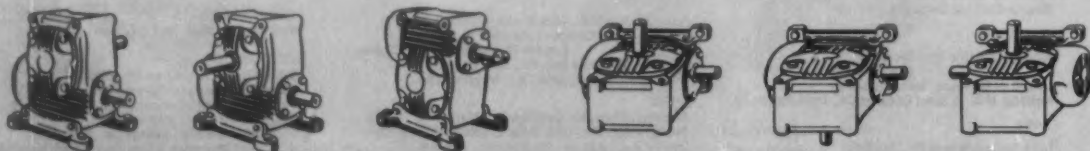
- ▶ 12 sizes—Center Distances from 1 $\frac{1}{4}$ " to 8"
- ▶ Rated to **NEW AGMA Standards**
- ▶ Ratios from 5:1 to 70:1
- ▶ Output torque to 46,000 lb. in.
- ▶ Input capacities from .01 to 66 HP

Foote Bros. RADICON Worm Gear Reducers incorporate *totally new* concepts of speed reducer design and construction. From the inside out and top to bottom, they embody years ahead thinking to provide users with more efficient, more versatile right angle power transmission in minimum size units.

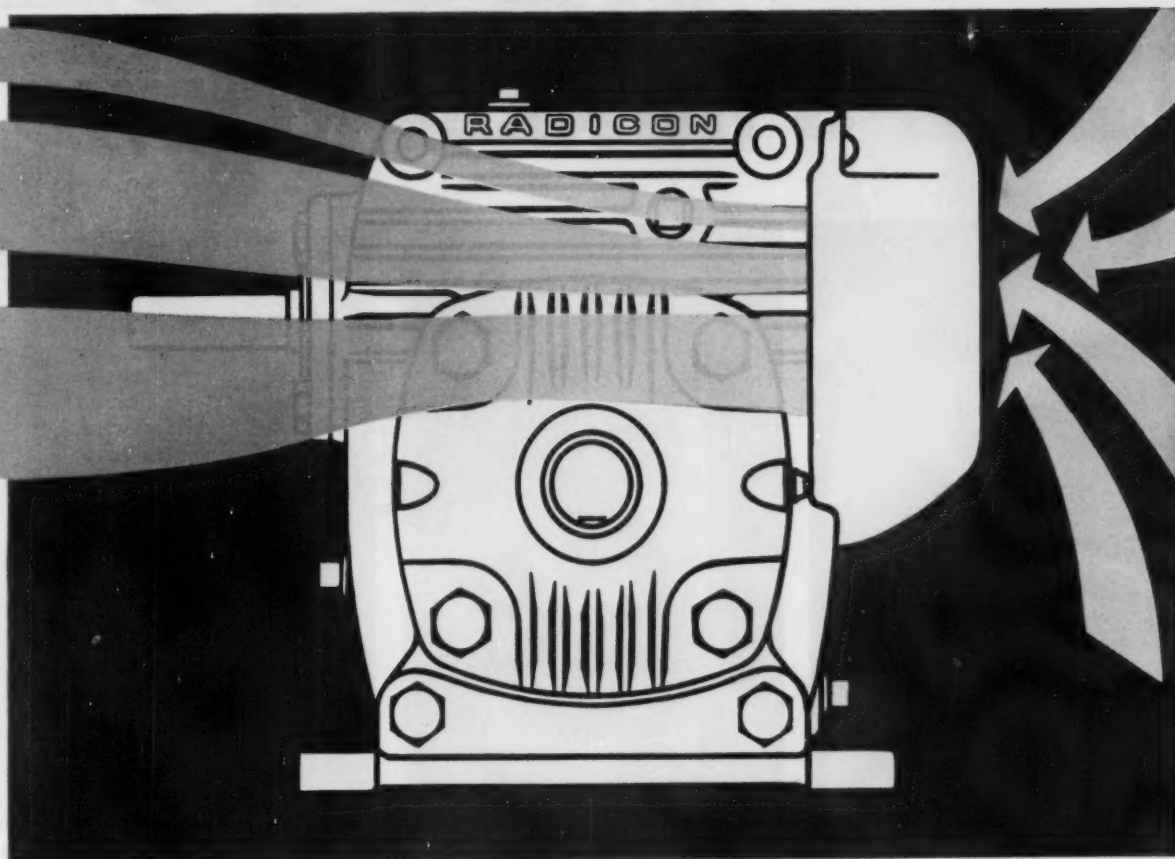
Gear accuracy and surface finish, bearing and shaft design, positive lubrication, extreme efficiency controlled cooling, the selection of materials and precision manufacturing techniques—all reflect careful attention to detail that results in higher load carrying capacity and maximum service life.

These outstanding new fan-cooled worm gear reducers are available now—carried **IN STOCK** by Authorized Foote Bros. Distributors for **IMMEDIATE DELIVERY**. See them soon. Get complete details on the performance, versatility, and service life they will bring you. Write for RADICON Catalog.

### UNLIMITED MOUNTING POSITIONS



## **COMPLETELY NEW and ADVANCED line of WORM GEAR REDUCERS**



### **RADICON Reducers operate in a STREAM OF AIR for maximum thermal efficiency**

Advanced design of RADICON Worm Gear Reducers and their high efficiency radiation and convection cooling for controlled transfer of heat to the outside air, permit *identical* thermal and mechanical ratings in most cases. For infrequent or intermittent service, thermal ratings can be ignored.

A moving stream of air, induced by the maximum diameter fan, forcing high velocity cooling air along horizontal channels formed by the external ribbing, dissipates radiated heat to hold the Reducer's temperature rise to a minimum. Cooling is equally efficient at any mounting position.

**FOOTE BROS.**



**GEAR AND MACHINE CORPORATION**

4567 South Western Boulevard, Chicago 9, Illinois

**POWER TRANSMISSION DRIVES**



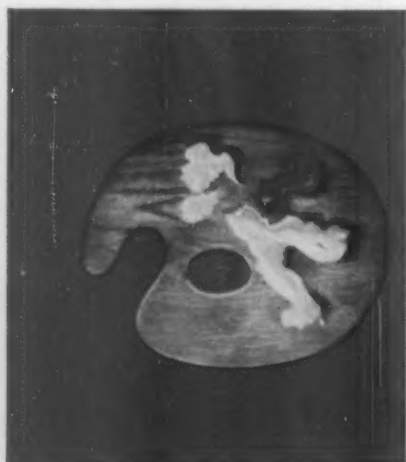
# ENJAY BUTYL

## IS TOPS IN ALL-'ROUND



### RESISTANCE TO CHEMICALS

Enjay Butyl, because of its unique and extremely low degree of unsaturation, offers excellent resistance to corrosive chemicals. The preferred rubber for tank linings, hose, seals, gaskets and other applications where exacting chemical resistance is required.



### VIVID COLORS

Enjay Butyl requires no additives for quality coloring over a wide range of hues. Famous for colorability and smooth finishes, Butyl has been successfully plastic coated for special applications.



### RESISTANCE TO TEAR AND ABRASION

Enjay Butyl offers the highest aged tear strength of any rubber . . . even after long exposure to ozone and heat! Its inherent toughness resists abrasive wear, in such applications as tires, conveyer belts, hose and other mechanical goods.

### RESISTANCE TO SUN-LIGHT AND WEATHERING

Enjay Butyl has proven its resistance to ultra-violet light, ozone, oxidation, moisture and mildew. Increases life of products such as weatherstrips, garden hose, wading pools and automotive parts.



# RUBBER

## PERFORMANCE



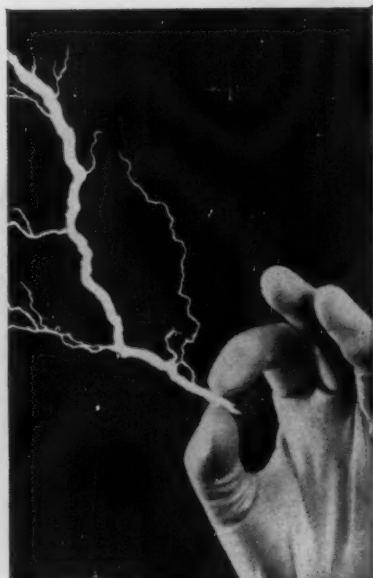
### DAMPING PROPERTIES

Enjoy Butyl absorbs shock and vibrational energy more completely than any other rubber. Resiliency can be varied in compounding and processing. Butyl is ideal for axle and body bumpers, motor mounts and sound-deadening applications.



### IMPERMEABILITY TO GASES AND MOISTURE

Enjoy Butyl is tops in impermeability to gases and moisture . . . retains air pressure 8 times better than natural rubber. Outperforms other rubbers in such application as inner tubes, jar and bottle seals, hoses and inflatable goods.



### ELECTRICAL RESISTANCE

Enjoy Butyl tops all vulcanizable rubbers in electrical and dielectric properties . . . in resistance to corona and ozone breakdown and water absorption. Its high dielectric strength insures against electric breakdown under normal or surge voltage. Its heat resistance permits higher current flow for a given conductor size.

The outstanding properties of Butyl Rubber create new horizons for the designer, and offer to manufacturers an opportunity to utilize the qualities of rubber in applications never before possible. The unique properties of Butyl have led to vast improvement in many existing products. Technical skills will open the way to countless new uses.

Butyl is the "idea" rubber with uses stretching as far as the imagination can reach. We'll be glad to tell you all about it. Just contact the nearest Enjoy office.

HOME OFFICE: 15 West 51st Street, New York 19, N. Y. OTHER OFFICES: Akron • Boston • Charlotte • Chicago • Detroit • Houston • Los Angeles • New Orleans • Tulsa

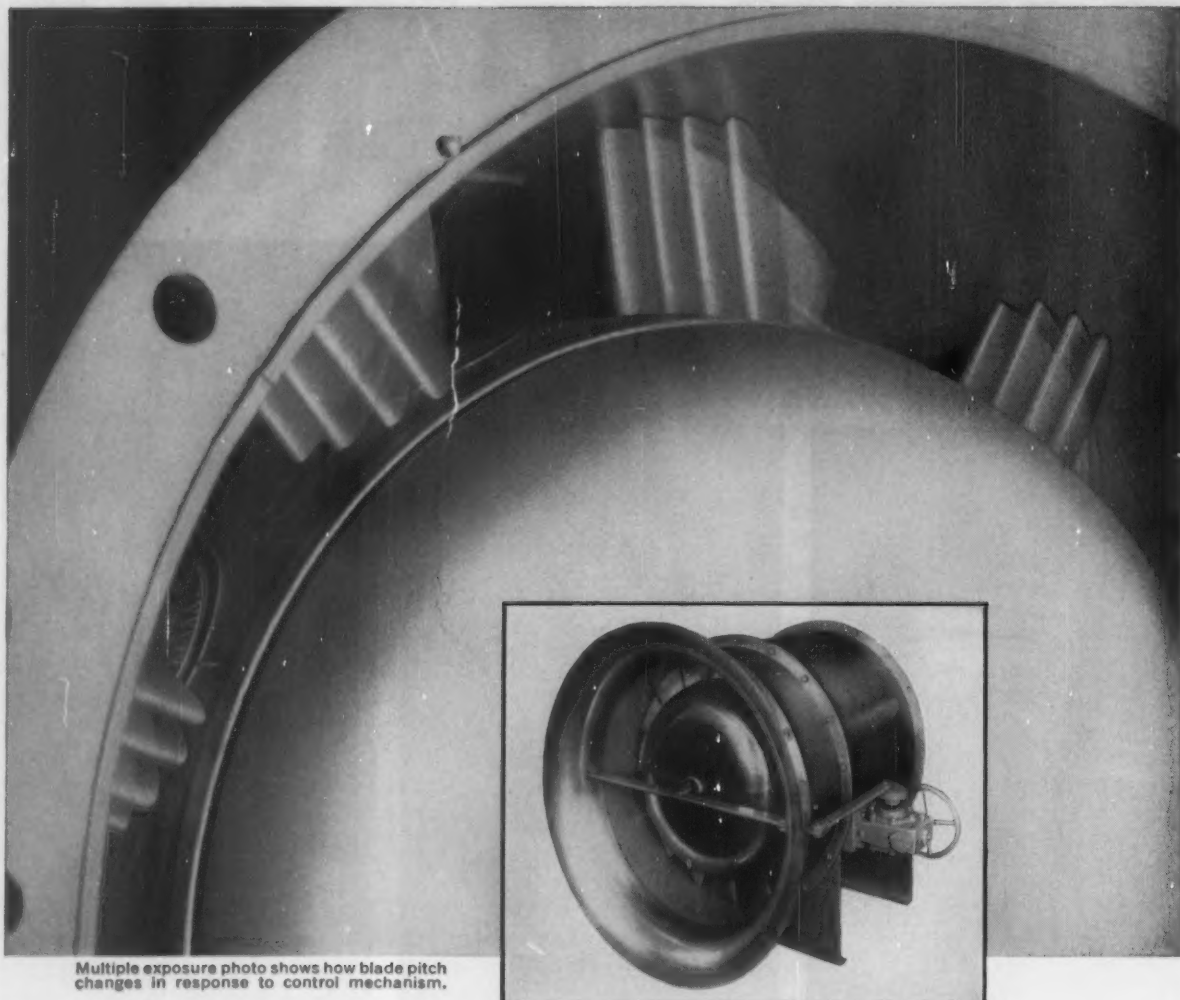


EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

**ENJAY CHEMICAL COMPANY**

A DIVISION OF HUMBLE OIL & REFINING COMPANY





Multiple exposure photo shows how blade pitch changes in response to control mechanism.

## Automatic Adjustment of Air Supply to CO<sub>2</sub> Concentration, Temperature or Humidity with Joy Controllable Pitch Axivane® Fans

The blade pitch on Joy Axivane Fans can be changed automatically while the fan is running, varying the air volume as much as  $\pm 20\%$ . The controlling mechanism can be linked to a sensing device to make air volume respond to a change in ambient temperature, humidity, concentration of a gas, or any of a number of conditions.

Controllable Pitch Joy Axivane Fans are ideal

for ventilation of vehicular tunnels and work areas in which noxious gases tend to collect, maintaining air cooled equipment at an even temperature, stabilizing moisture content in an area, or any application requiring a variable supply of ventilation air.

Write for complete details on how Joy Controllable Pitch Axivane Fans can be made to suit your particular situation. Ask for bulletin 289-64-B.



**AIR MOVING EQUIPMENT FOR ALL INDUSTRY**



Dust Collectors



Compressors



Ready-Span  
Conveyor



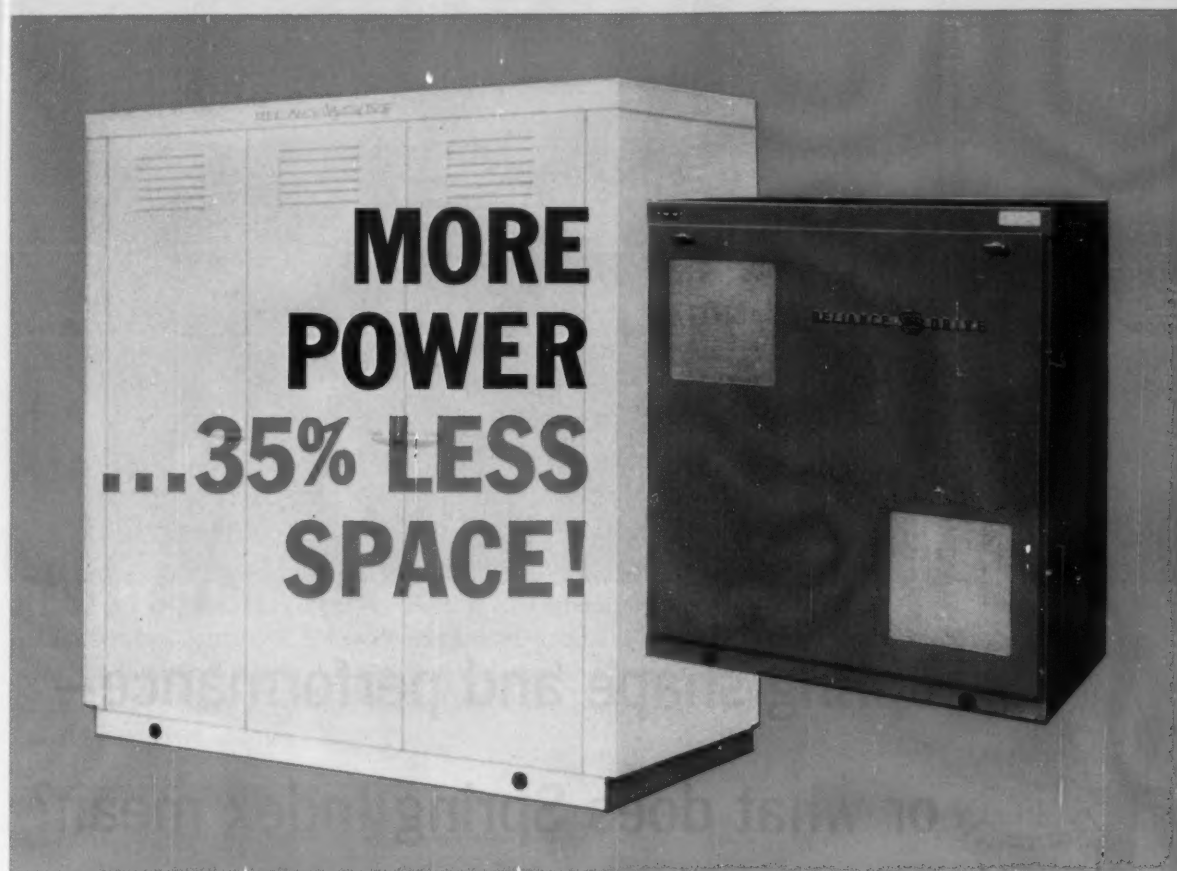
Fans and  
Blowers

# JOY

Joy Manufacturing Company  
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company  
(Canada) Limited, Galt, Ontario

# Reliance Super 'T' V\*S Drives



Both of these control units are rated at 50 horsepower! Actually, the new, small Super 'T' V\*S cabinet packs more punch!

**L**IKE the Reliance Super 'T' Drive Motor, new V\*S power units utilize Class B insulation, permitting a more compact unit. 100% overloads of one minute duration are accomplished without failure! Advanced design of ventilation keeps control and power units cooler . . . another reason why smaller size is possible. And service life is substantially extended.

Matched system design of drive motor,

power unit and controls produces a highly efficient, integrated drive—to give you a wide range of stepless, variable operating speeds from a-c. circuits.

Super 'T' V\*S Drives are available for immediate delivery. Check your Reliance salesman for delivery schedules on the full line, 1—350 hp., Bulletin Number D-2506, has been prepared to give you complete information. Write for it.

D-1041

Product of the combined  
resources of  
Reliance Electric and  
Engineering Company and its  
Master and Reeves Divisions

**RELIANCE ELECTRIC AND ENGINEERING CO.**

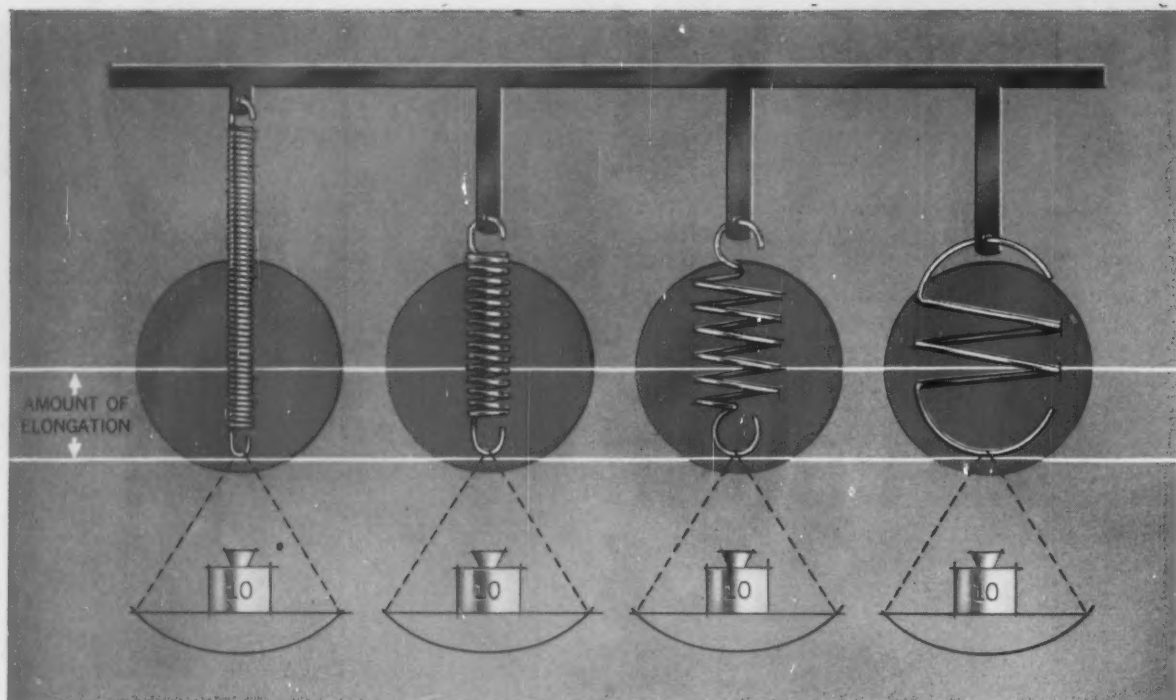
DEPT. 288A1, CLEVELAND 17, OHIO

Canadian Division: Toronto, Ontario

Sales Offices and Distributors in Principal Cities



Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V\*S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.



## Spring shape and performance— or what does Spring Index mean?

One man distributes his 150 lbs. over a lean 6 ft. frame; another packs the same avoirdupois within a stocky 5 ft. 6 in. height. In a man, this might be expressed as the ratio of height to belt size. In a spring, it's a handy little ratio  $D/d$ , that of mean coil diameter to wire diameter. The illustration shows it quickly—same load—10 lbs.; same deflection—0.4 in. But in shape they range from the long thin spring at

left with 75.8 coils and a spring index of 3, to the short fat spring at right with few coils and an index of 12. Application of the index ratio is particularly useful where space restrictions exist.

Our long years of specialization have developed many short cuts to spring specification to make your work easier. For general reference purposes write for pamphlet "Spring Design and Selection in Brief."

### Associated Spring Corporation



General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.

F. N. Manross and Sons Division, Bristol, Conn.

Dunbar Brothers Division, Bristol, Conn.

Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

Raymond Manufacturing Division, Corry, Penna.

Ohio Division, Dayton, Ohio

Cleveland Sales Office, Cleveland, Ohio

Chicago Sales Office, Chicago 46, Ill.

B-G-R Division, Plymouth and Ann Arbor, Mich.

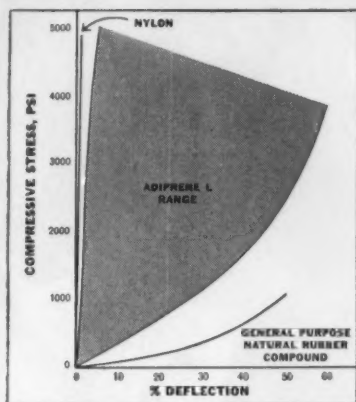
Gibson Division, Mattoon, Ill.

Milwaukee Division, Milwaukee, Wis.

Seaboard Pacific Division, Gardena, Calif.

# ADIPRENE®

*new Du Pont liquid urethane elastomer*

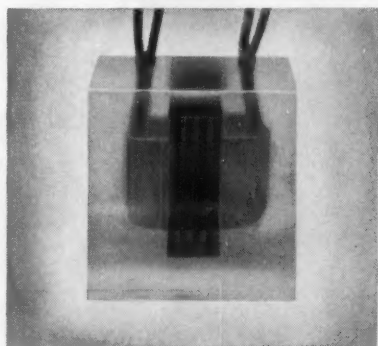
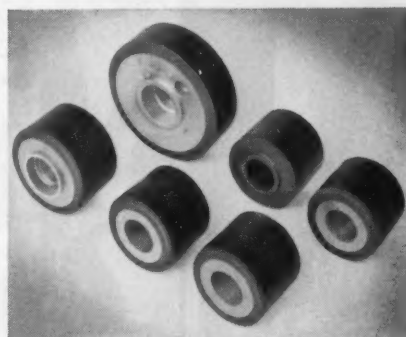


## CARRIES A HEAVY LOAD

An outstanding attribute of this new Du Pont synthetic rubber is its combination of toughness, high load-carrying ability and resilience. Load-bearing capacities of hard ADIPRENE L compounds far excel those of general purpose synthetic rubbers.

## RESISTS ABRASION

Both in the laboratory and in actual service, ADIPRENE L has demonstrated its ability to resist wear. On industrial wheels it has outlasted natural rubber as much as 10 times . . . has more than doubled service in pump impellers handling abrasive slurries.



## NOT BRITTLE AT "EIGHTY BELOW"

ADIPRENE L vulcanizates maintain their resilience at  $-20^{\circ}\text{F}$ . . . and do not become brittle at temperatures as low as  $-80^{\circ}\text{F}$ . They exhibit outstanding resistance to thermal shock, and will operate at intermittent temperatures as high as  $250^{\circ}\text{F}$ .

## OTHER PROPERTIES

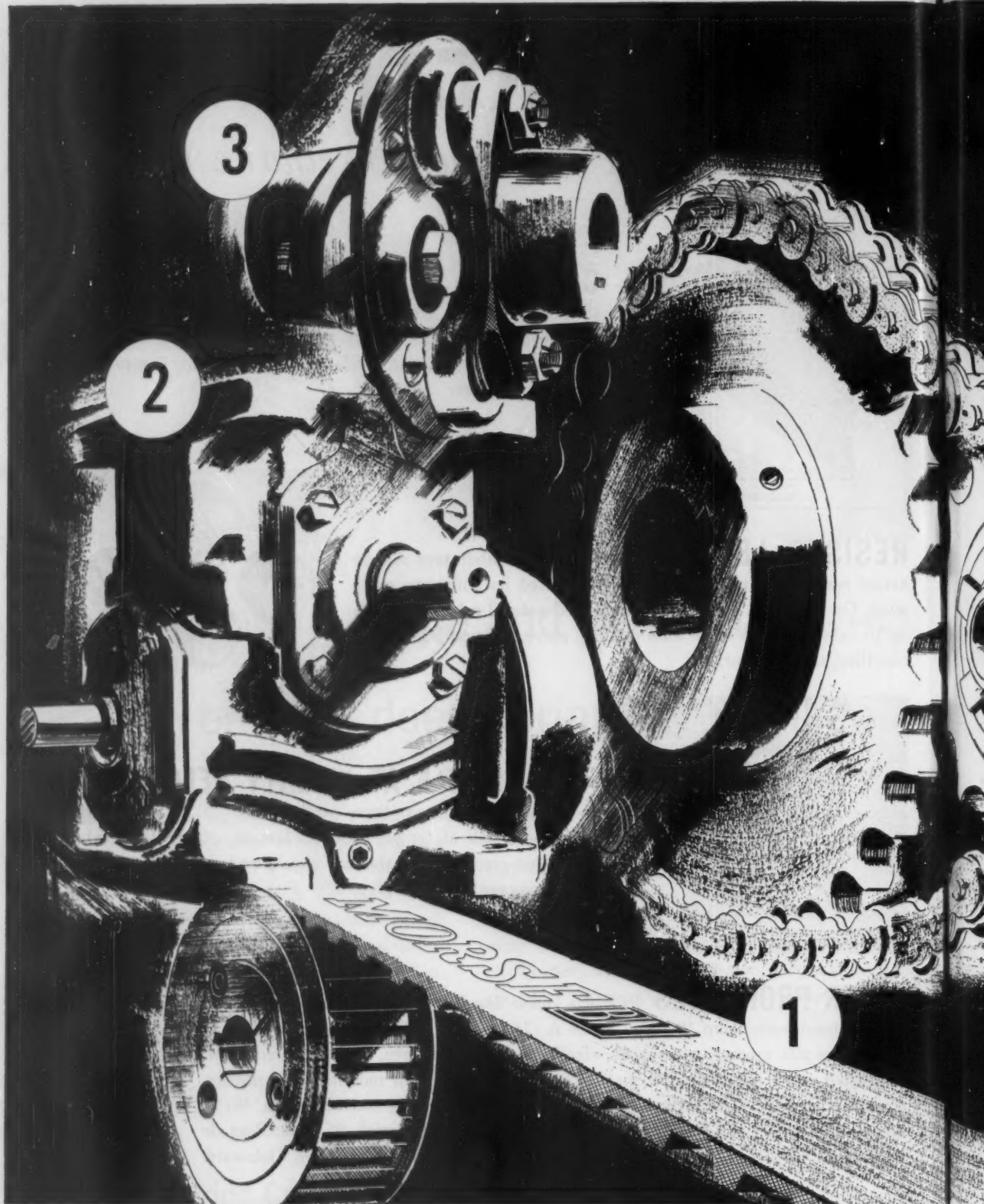
Products made from ADIPRENE L are available in various hardnesses from 10 to 99 Shore A (78 Shore D). They resist the action of lubricating oils, greases, weak acids, alkalies, as well as oxygen, ozone and radiation. Suggested uses for ADIPRENE L include industrial rolls, motor mounts, seals, potting compounds, solid tires, striker plates, wear-resistant linings and coverings. Write for booklet on properties and applications of this new material. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-8, Wilmington 98, Delaware.



**SYNTHETIC RUBBER**  
NEOPRENE HYPALON® VITON® ADIPRENE®

Better Things for Better Living . . . through Chemistry





**ONLY MORSE  
OFFERS ALL 4**

**1 BASIC DRIVES**

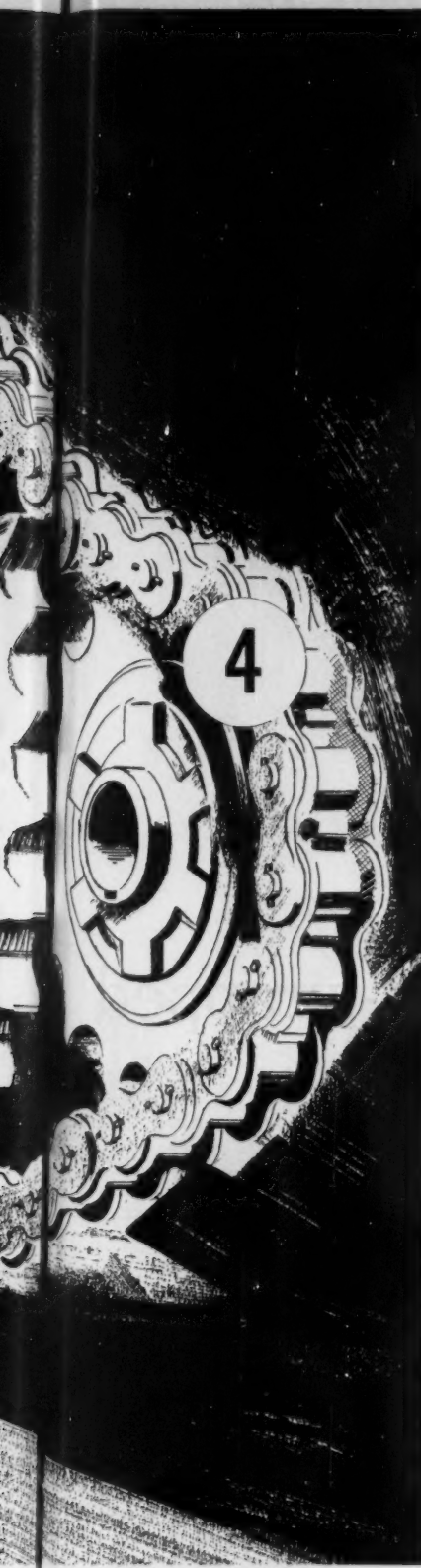
Morse offers a complete line of Roller Chain, Silent Chain, exclusive Hy-Vo® Drives, "Timing"® Belts and Sprockets.

**2 SPEED REDUCERS**

Eberhardt-Denver "RW" PowerGear® Reducers, Gearmotors, Worm Gear Reducers, Conveyor Drives, Mitre Boxes, Helical Reducers.

**3 COUPLINGS**

Flexible Roller and Silent Chain Couplings; Morflex Couplings, single and double; Morflex Radial and Marine Couplings.



Only Morse offers all 4 . . . only Morse can accept

## Full responsibility for your industrial power drive

Drives, speed reducers, couplings and clutches . . .  
designed better, built better, distributed better and backed by the  
only company that takes on the whole job of satisfying you

If you have a production process that requires transmission of mechanical power, it just makes good sense to deal with a company that can take on the *whole* job—furnish *all* the components—guarantee your satisfaction with the *complete* power train.

And *only* Morse can do it!

Drives, speed reducers, couplings and clutches: Morse designs them better to work together . . . builds them better to high quality standards for longer life, in a wide variety of sizes and capacities ideally suited to any job. Moreover, Morse distributes them better for broader, faster customer availability.

Morse—the No. 1 supplier of automotive timing chains—has, through

continuous expansion, evolved a complete line of exclusive power-transmission products. Among them, the well-known Morflex couplings . . . H-E roller chain . . . Hy-Vo® drives . . . Rockford Clutches, Eberhardt-Denver speed reducers and full line of components for the broad industrial fields.

Whether your next project calls for a single coupling or a complete power train, your Morse distributor is the man who can help you most. He's always nearby, listed in the Yellow Pages. Or, if you wish, write direct: Morse Chain Company, Dept. 6-80, Ithaca, New York. Export Sales: Borg-Warner International, Chicago 3, Illinois. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.

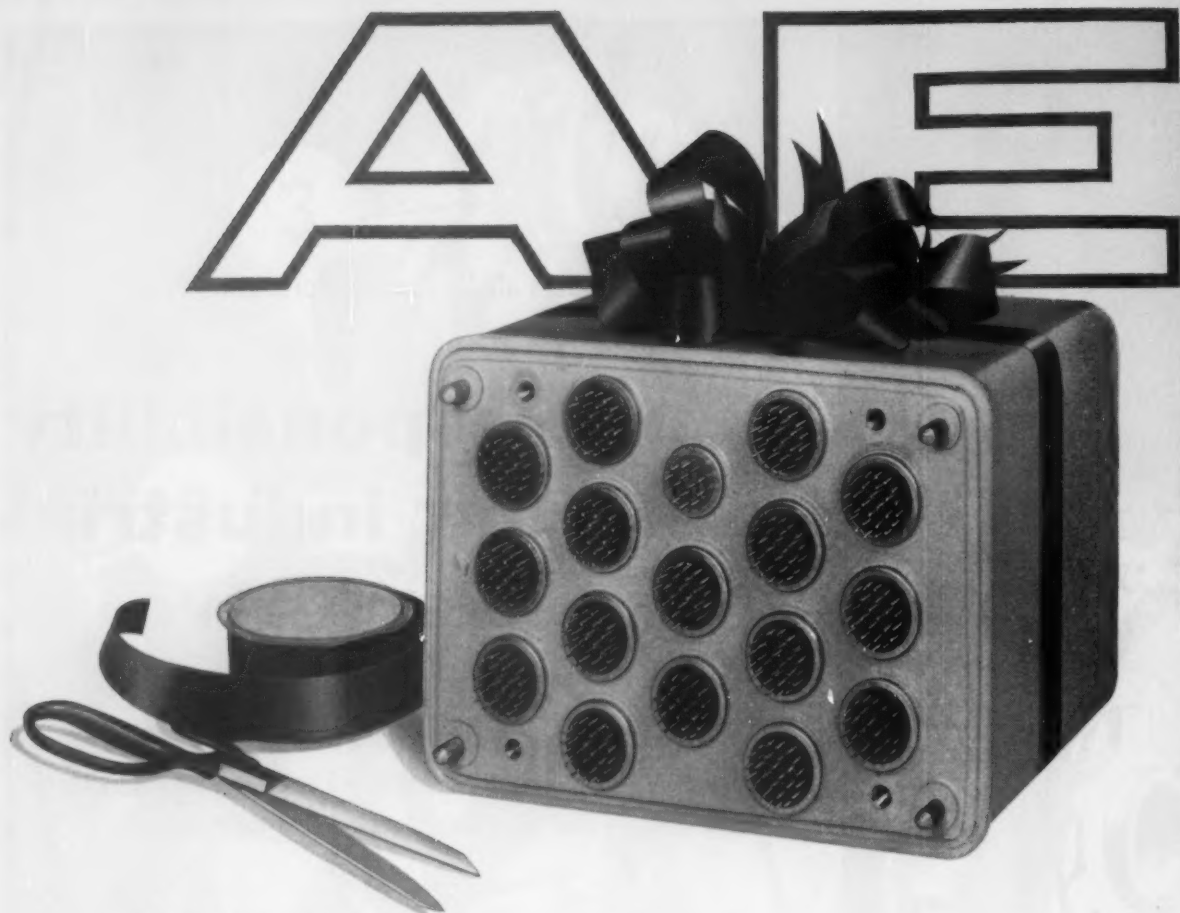
### 4 CLUTCHES

Morse Cam (Over-Running, Back Stopping, Indexing), Pullmore, Over-Center, Torque Limiter and Centrifugal Styles afford flexible control of power.

# MORSE



## A BORG-WARNER INDUSTRY



## TO THE ENGINEER who likes his switching gift-wrapped

If you want your control functions prewired, hermetically sealed in a neat package, tested out, and as ready as instant coffee, you're listening to the right people.

Because AE has a gift for wrapping up relays and stepping switches in tidy control packages of your design—or ours, if you prefer.

For instance, the control package illustrated houses an AE Type 45 Rotary Stepping Switch wired to multiple-pin headers for direct plug-in (and we supply the properly oriented socket mounting plate). This particular job has 462 connections, and could just as readily be equipped with MS connectors for insertion in matching cable plugs.

The point is, we've been wiring telephone switchboards and automatic control devices for years, and have the technique down pat. So pat that it would probably cost you less to let *us* do the job.

Besides, AE engineers are past masters at designing complex switching circuits. You can leave it to them, if you wish, to dope out the least expensive way of accomplishing the most sophisticated switching.

How about letting us in on *your* control problem? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Catalog 4083: "Hermetically Sealed Relays and Switches."

**AE  
CAN  
DO**



**AUTOMATIC ELECTRIC**

Subsidiary of

**GENERAL TELEPHONE & ELECTRONICS**





# OPENING NEW HORIZONS

*in economical power application*

98% PLUS OPERATING EFFICIENCY  
MORE POWER PER CYLINDER DOLLAR  
PROVEN LEAKPROOF OPERATION  
GREATEST SELECTION EVER OFFERED  
SAFE UNDER SEVERE LOADS  
SAFE WITH ALL KNOWN HYDRAULIC FLUIDS  
SAFE UNDER TEMPERATURE EXTREMES  
DAMAGE-PROOF PISTON RODS

## Miller HYDRAULIC CYLINDERS



Flick-Reedy... Winner of "Plant of the Year" Award and "Silver Anvil" Public Relations Award



### MORE SAVINGS!

Our ultra-modern, new "Plant of the Year" with its special facilities and operating economies enable us to offer an extra 10% price savings on our big "stock" selection of:

Model "H" (Hyd.) Cylinders, 1½" through 8" bores;  
Model "J" (Hyd.) Cylinders, 1½" through 14" bores;  
Model "A" (Air) Cylinders, 1½" through 14" bores.  
Strokes up to 36", cushioned and non-cushioned.

Full Details On Request

Miller Hydraulic Cylinders make impossible applications look easy. With Teflon Seals, Case-Hardened Rods (50-54 Rockwell C), Patented "Shel" Tubing End Seals, and other exclusive *standard* features, these cylinders are practically damage-proof, are ultra-dependable under pressure and temperature extremes, and provide leakproof sealing with ALL hydraulic fluids. Built to *exceed* J. I. C. Specifications, these cylinders are achieving new highs in production and operating economies in thousands of plants. Two great lines: Power-Packed Model H for 3000-5000 psi and Job-Rated Model J for 500-2500 psi. All bores, strokes and mounting styles. Big "Stock" selection for immediate shipment at substantial savings.

*Write for literature.*



## MILLER FLUID POWER

DIVISION OF FLICK REEDY CORPORATION

7N016 YORK ROAD, BENSENVILLE, ILLINOIS

AIR AND HYDRAULIC CYLINDERS • ACTUATORS  
COUNTERBALANCE CYLINDERS • BOOSTERS



# INTRODUCING...

# XEROX COPYFLO 1824 PRINTER



XeroX Copyflo 1824 Printer



... small-volume users can drastically reduce the cost of engineering-drawing reproduction.

Now, regardless of your engineering-drawing-reproduction needs, you can enjoy the tremendous savings in time, space, and materials of a unitized microfilm system.

Formerly, such economies... from \$20,000 to \$100,000 annually... required a substantial volume of reproduction to make the system feasible.

Today, an ingenious new xerographic device called a XeroX® Copyflo® 1824 printer brings the same proportionate benefits to small-volume users as to large.

The Copyflo 1824 printer makes 18" x 24" prints, or smaller, on *ordinary paper* at an extremely low cost. Also reproduces on velum and offset paper masters.

Operation is automatic. Prints emerge dry, ready for immediate use, as fast as four a minute. And the quality of reproduction is excellent. The image is black-on-white and is permanent. There is no odor, no waste and the paper may be written on with pencil or pen.

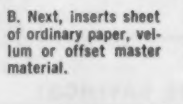
No need now for vast files of engineering drawings. Microfilm aperture cards take only a fraction of the space required for other types of reproducible. And, xerographic prints are so inexpensive, your engineers can discard them after use.

Write today for 1824 booklet giving the full benefits you can expect from a Copyflo 1824 printer. HALOID XEROX INC., 60-114X Haloid St., Rochester 3, N. Y. Branch offices in principal U. S. and Canadian cities. Overseas: Rank-Xerox Ltd., London.

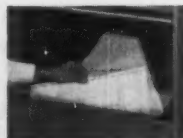
## SIMPLE AS ABC



A. Operator inserts microfilm aperture card.



B. Next, inserts sheet of ordinary paper, velum or offset master material.



C. The first print is automatically delivered in 30 seconds, subsequent prints (of the same or different drawings) every 15 seconds.

# HALOID XEROX®

Circle 479 on Page 19

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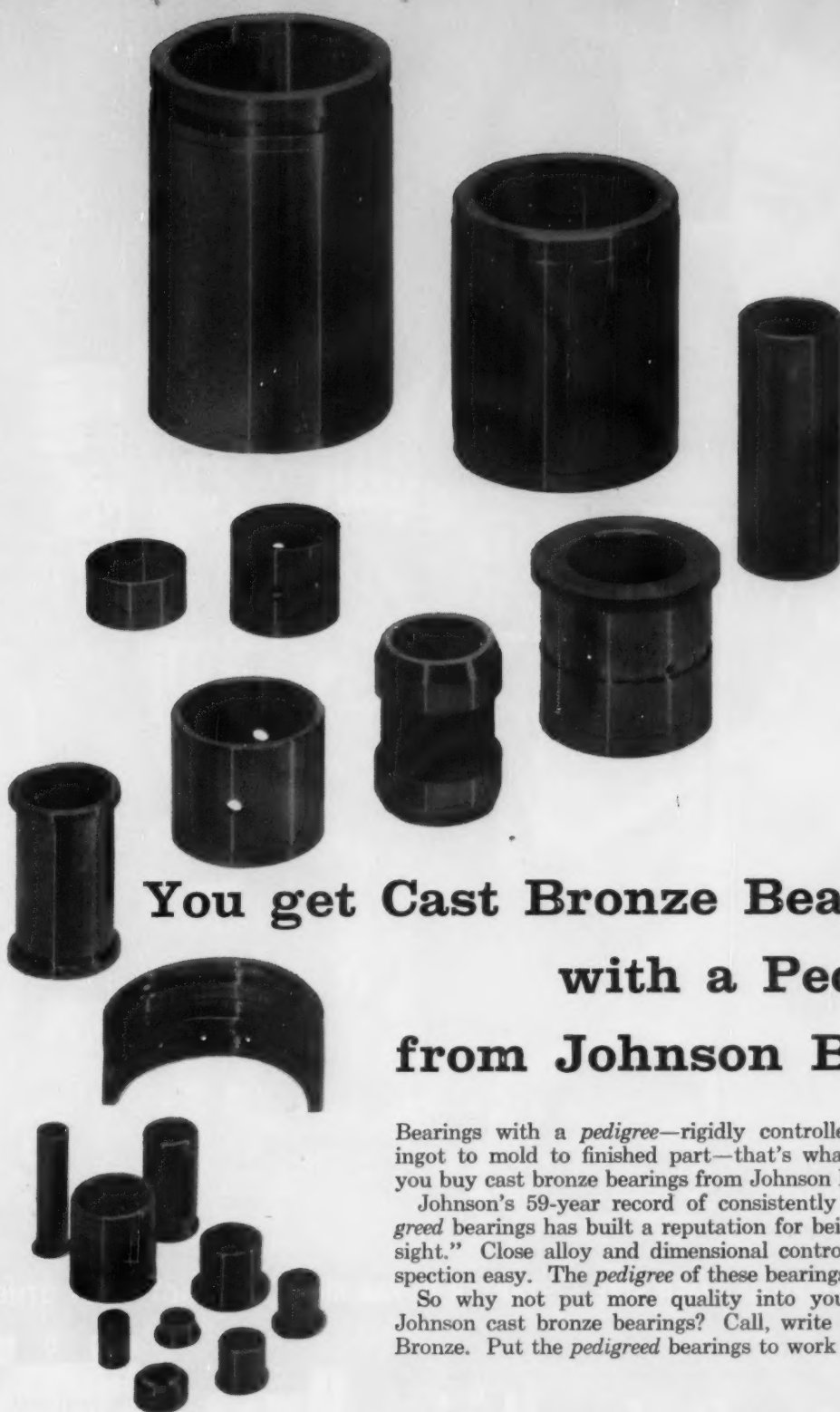
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## You get Cast Bronze Bearings with a Pedigree from Johnson Bronze

Bearings with a *pedigree*—rigidly controlled quality from ingot to mold to finished part—that's what you get when you buy cast bronze bearings from Johnson Bronze Co.

Johnson's 59-year record of consistently supplying *pedigreed* bearings has built a reputation for being "accepted on sight." Close alloy and dimensional control make your inspection easy. The *pedigree* of these bearings tells you why.

So why not put more quality into your product with Johnson cast bronze bearings? Call, write or wire Johnson Bronze. Put the *pedigreed* bearings to work for you.

# Johnson Bronze Company

New Castle, Pa.

West Coast Plant: Oakland 8, Calif.



THE NEW CUTLER-HAMMER SIZE 5 STARTER IS FAR MORE COMPACT THAN OTHERS

NEW  
CUTLER-HAMMER  
SIZE 5



PANEL AREA  
197 SQ. IN.

VOLUME  
1480 CU. IN.



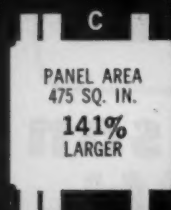
PANEL AREA  
270 SQ. IN.  
**37%  
LARGER**

VOLUME 2540 CU. IN.  
71% LARGER



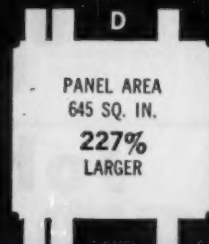
PANEL AREA  
322 SQ. IN.  
**63%  
LARGER**

VOLUME 2820 CU. IN.  
90% LARGER



PANEL AREA  
475 SQ. IN.  
**141%  
LARGER**

VOLUME 5750 CU. IN.  
224% LARGER



PANEL AREA  
645 SQ. IN.  
**227%  
LARGER**

VOLUME 5775 CU. IN.  
288% LARGER



# Now! A complete line of easy-to-install Cutler-Hammer Starters including a new compact Size 5

*7 sizes for use as components or as complete starters*

*(Size 00, 0, 1, 2, 3, 4 and 5)*

Now get all the advantages of Cutler-Hammer's Three Star starter line in seven sizes. You can control motors from fractional hp up to 200 hp, now that the new Size 5 is available.

**The new Size 5** starter needs only an eight-inch deep case. Its open dimensions are only 13" wide, 15 3/16" high, 7 1/2" deep . . . and is available as a non-reversing or reversing starter or as a contactor.

Even the wiring's easier. Instead of struggling to force the line and load cables into the lug connectors, the lugs unbolt, and are easily reassembled.

You still get, of course, the famous Three Star advantages that have made Cutler-Hammer Starters so famous: dependable

pivoted armature, vertical contacts that don't collect dust, ease of installation, ease of inspection and maintenance, plus many other features.

Be sure to send for Pub. LO-69-Q243 to get all the facts on the complete Cutler-Hammer Starter line.

#### **What's New at Cutler-Hammer?**

There's a new spirit here. You can see it in the new products, the new engineering talent, the increased plant capacities. We're ready for the great growth of the sixties so you can be ready to meet the great demands upon your capacities. We'd like to tell you more. Contact the Cutler-Hammer electrical distributor or the Cutler-Hammer sales office nearest you.

**WHAT'S NEW? ASK...**

## **CUTLER-HAMMER**

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.







# Presenting!

## NATIONAL BUD UNITIZED

TRADE MARK

Flanges, if desired, are available to simplify positioning and removal



National BUD UNITIZED has integral wear ring presenting rubber surface to shaft. Wear ring turns with shaft, sealing lip is never exposed to damage, cannot score shaft.

### A new unitized oil-seal-and-wear ring that eliminates:

**SHAFT WEAR OR SCORING**

**SEPARATE METAL WEAR SLEEVES**

**EXPENSIVE SHAFT FINISHES**

**COSTLY SHAFT RE-MACHINING**

**SEALING LIP INSTALLATION DAMAGE**

**SPECIAL INSTALLATION PROCEDURES**

New National BUD UNITIZED seals are now in production, in a limited range of sizes, for heavy oil and grease sealing applications — including truck, bus and tractor uses. Still newer BUD UNITIZED seals are on the way for higher speed automotive and similar uses.

Changing a National BUD UNITIZED oil seal automatically changes the wear sleeve — in one fast, simple operation. Since the seal has its own integral

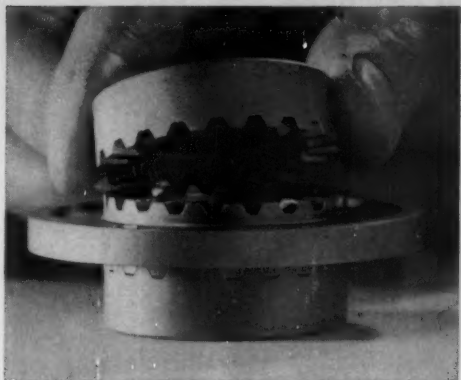
wear ring, it is almost impossible to install it other than squarely on the shaft. Expensive shaft finishing is no longer a necessity, nor is leakage under a metal wear ring a problem — both thanks to the rubber surface BUD UNITIZED presents to the shaft.

For complete details or skilled engineering help on application of BUD UNITIZED seals, write direct, or call your National Seal Applications Engineer. You'll find him in the Yellow Pages, under Oil Seals.

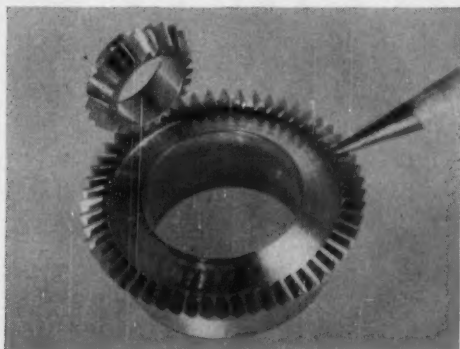
### NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.  
General Offices: Redwood City, California  
Plants: Van Wert, Ohio, Redwood City  
and Downey, California





**CURVIC COUPLINGS** provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.



**BEVEL GEARS**

## When a gear or a coupling determines the *accuracy of trajectory*...

When a missile or rocket works on paper the best way to get it into the air is to see to it that all the parts agree with the paper work.

And when one of those parts is a bevel gear or coupling, Gleason engineers can help you three ways:

**1. Engineering service.** Our full staff of engineers is ready at all times to help you develop bevel gear combinations and Curvic® Coupling designs. They can help you make sure that either part meets your specifications.

**2. Machines to cut or grind to your tolerances.** You can produce any fine pitch gear—spiral bevel, hypoid, Zerol® or Coniflex®—precisely and economically with any of five Gleason machines.

No matter how rigid your specifications or the size of your parts, our engineers can help you select the right machine or combination of machines for 100% accuracy.

**3. Complete testing equipment.** We have engineered a series of testers for making certain that all parts do meet your critical specifications. For example,

on the Gleason No. 104 Hypoid Tester you obtain a permanent test record to help you match pairs properly and to keep a graphic record of the rolling qualities, tooth spacing, and concentricity of your parts.

Any or all of these services are yours for the asking at any time.



**GLEASON WORKS**

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.



## CUTICLES TO CONCRETE

### Flexible shafts carry torque to spare...

Whether your product requires delicacy or raw strength, there's a flexible shaft available from S. S. White to transmit rotary power or control.

For example, the .043" dia. flexible shaft in the manicurist's tool transmits approximately 0.38 pound-inches at high speed and provides extreme flexibility of operation—suitable to M'Lady's finger-tips. Or, consider the Viber Concrete vibrator which needs a .437" dia. shaft, capable of transmitting high torque at 10,000 rpm under brutal field conditions.

Keep flexible shafts in mind for applications other than power tools, too. They allow the designer important—sometimes vital—latitude in positioning both power source and driven part... freedom to snake power around ob-

stacles, freedom to obtain balance and structural economy.

Flexible shafts solve a lot of other problems too. They help you to eliminate parts... expensive, cumbersome gears, drives, universals. Make installation easier because they have no alignment problems. Machine performs better too, because vibration, shock, overloads are absorbed by rugged flexible shafts.

Whatever your problems, look into S. S. White's three lines of flexible shafts: Standard... Pre-Engineered... Custom-Designed. There's bound to be an answer for you.

**S. S. White Industrial Division, Dept. 4  
10 East 40th Street, New York 16, N. Y.**



#### WRITE FOR COMPLETE DATA

Standard S. S. White flexible shafts are available "off the shelf," making many savings possible. Write for bulletin 5601.

S. S. White also offers engineering service and comprehensive selection of flexible shaft sizes and types to meet special requirements. Write for bulletin 5601.

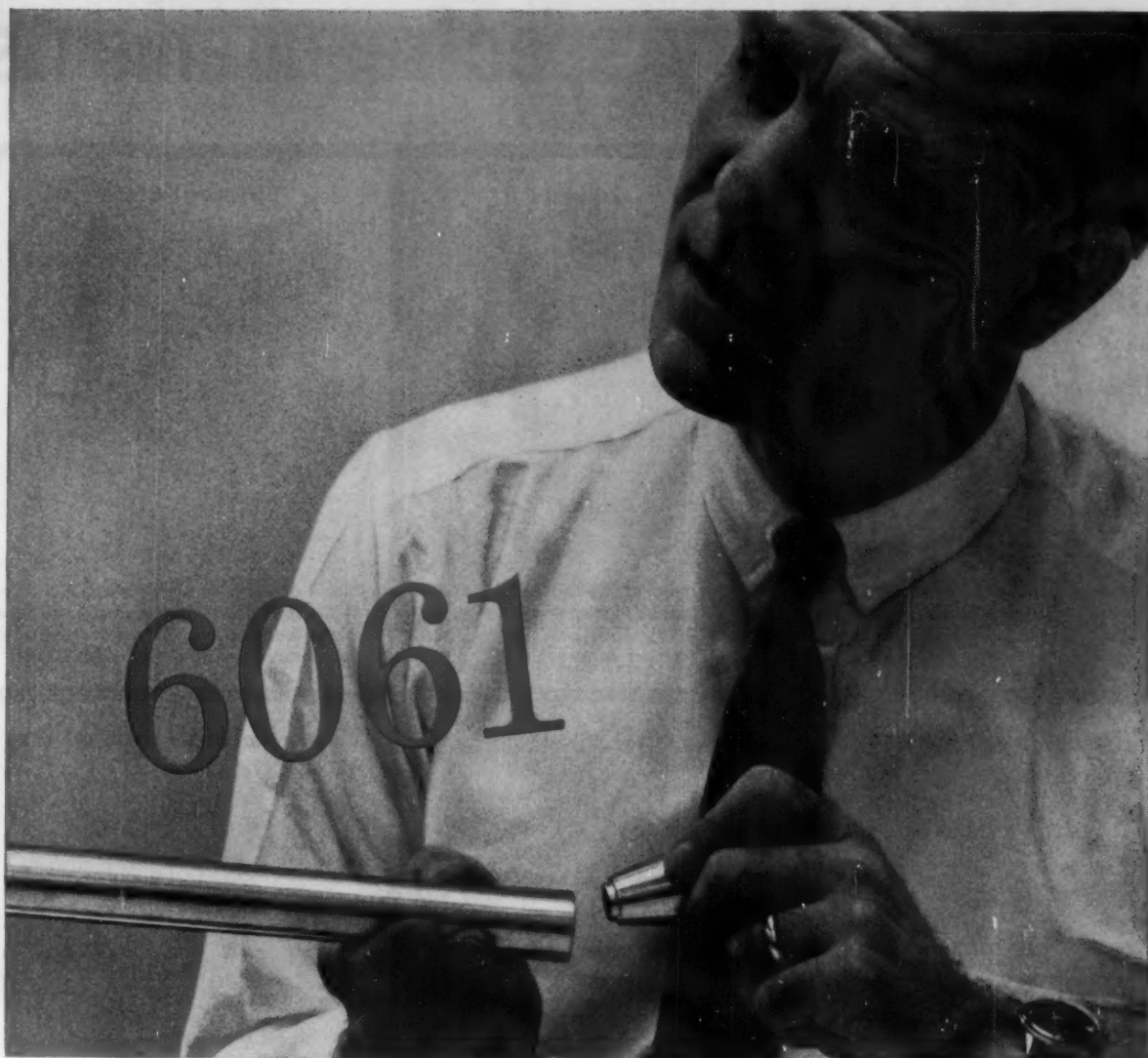
**S.S. White**

FIRST NAME

IN FLEXIBLE SHAFTS

1121





## "ALCOA ALUMINUM SCREW MACHINE STOCK ALLOY 6061... FOR VERSATILITY!"

Precision-made, high-volume screw machine parts cost less in aluminum

Here's versatility! Alcoa Alloy 6061-T6 or -T651, being lightweight aluminum, gives you three times more parts per pound than other, heavier metals. And this alloy gives *superior* finishes... can be joined easily by welding, brazing or soldering... may be anodized in a wide variety of colors... stands up to service under corrosive conditions! Machining speed, light weight and end-use adaptability... all add up to faster production, lower machining costs, higher profits.

Want to make cost conversions from brass to aluminum and compute costs quickly? Ask your Alcoa distributor or Alcoa sales office for your free *Alcoa Conversion Calculator*. Get your free *Alcoa Screw Machine Stock Estimating and Operating Data Book*, too... packed with technical data on aluminum screw machine stock. And ask about other Alcoa alloys: 2011-T3 or -T8 for superb machinability and still faster cutting, 2017-T4 or -T451 and 2024-T4 or -T351 for strength at

low cost. Aluminum Company of America, 840-H Alcoa Building, Pittsburgh 19, Pa.

### AS AN ALCOA CUSTOMER, YOU GET ALL THESE "EXTRA BONUSES":

1. Wide range of stock sizes for important price advantages.
2. Guaranteed market for up to 60 per cent of your Alcoa® Aluminum turnings and borings.
3. Extensive mill and distributor inventories to meet all requirements.
4. Chamfered ends at no extra cost.
5. Specific 12-ft lengths at no extra cost (for rounds up to 2¾ in.; hexagons up to 2 in.).



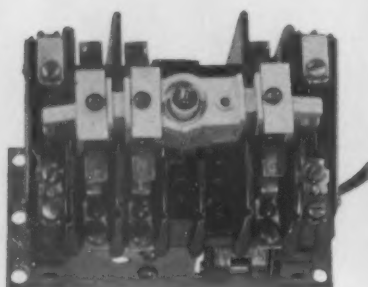
**ALCOA ALUMINUM**

SCREW MACHINE STOCK



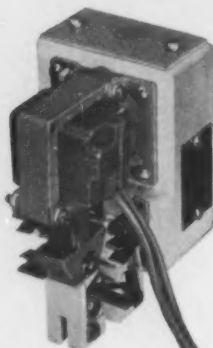
# Meet military spec requirements

## AC contactors



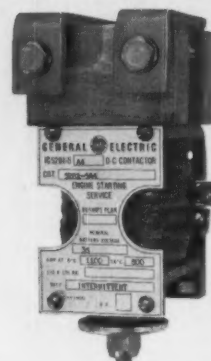
For magnetic operation on motor loads through 200 hp at 440 volts, 3-phase, 60-cycle; are available with 3 or 4½ poles.

## AC relays



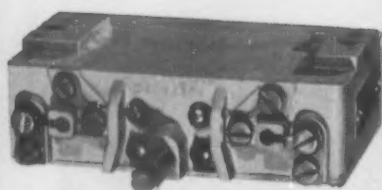
Interlocking or undervoltage relays; available with four to eight poles in ratings to 10 amps; both single-pole (above) and multi-pole contact arrangement.

## DC contactors



Diesel-starting (above), time-delay, sizes 1, 2, and 3 for magnetic operation on motor loads through 25 hp at 230 v d-c. Submarine service forms available.

## Thermal overload relays



Both heater- (above) and induction-type; adjustable from 90 to 110 percent of rating; resetting time 60 seconds after tripping.

## Reset relays



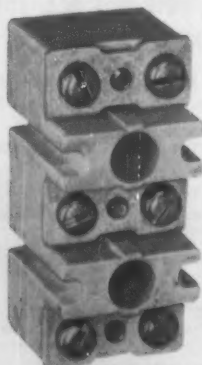
A remote method for resetting overload relays; consist of potted solenoid coil and a mechanical linkage on corrosion-resistant steel base with insulated leads.

## Panel-mounted pushbuttons



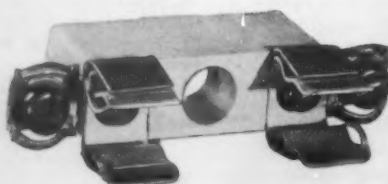
For use on a-c or d-c circuits where momentary contact is required; available in standard or oiltight forms in variety of contact arrangements.

## Terminal boards



Designed for 25-, 50-, 100-, and 150-amp circuits. Termination points—either 2, 3, 5, 7, or 9—have fire-resistant base.

## Fuse blocks



Rated up to 30 amps; blocks consist of a fire-resistant molded-compound base with metal terminals and fuse clips; convenient single-hole mounting.

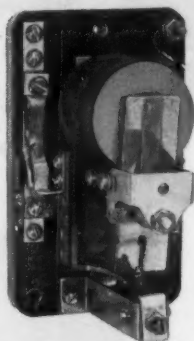
## Resistors



Starting and regulating duty on motor and generator field adjustment, load banks, etc.; available in ratings from 21.5 to 42.5 amps continuous and five lengths.

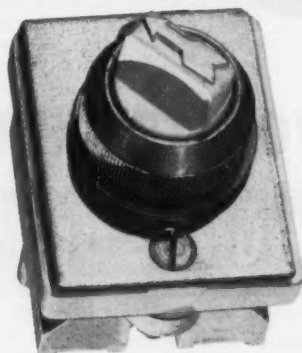
# s with General Electric HI-shock control components

DC relays



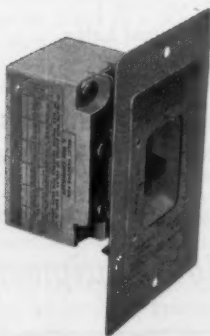
Multi-current and overcurrent relays (above) are used as interlocking or under-voltage relays, and on electronic applications requiring shock-damage design.

Panel-mounted selector switches



For use on either a-c or d-c circuits where maintained contact is required; available in three forms; can be mounted on panels up to 3/16-inch thick.

Manual starters



For single-speed, 1- or 3-phase, squirrel-cage induction motors or d-c motors. Size 0 starters are drip-proof or flush-mounted; rated 3 hp 440-volt a-c maximum.

**A complete line of devices designed for extreme environmental applications**

- Shock
- Humidity
- Fungus
- Vibration
- Tilting
- Temperature

Whether you're designing equipment to meet exacting Navy specifications . . . or for missile hard-site applications where adverse environmental conditions are inherent . . . one or more of General Electric's HI-shock control components may well be the answer to your circuit design problems.

All General Electric HI-shock control components are designed, built, and tested to perform reliably in virtually all operating conditions including shock, humidity, fungus, vibration, tilting, and high or low temperature.

Outstanding features you get with the complete line of General Electric HI-shock control devices include: 1) all front connection for easy servicing; 2) fire-resistant compound bases, and 3) all corrosion-resistant metal parts.

## CATALOG OFFERS COMPLETE DESIGN DATA

General Electric's Control Components Catalog contains dimensional outlines, electrical design data, environmental limits, MIL Spec references, and prices on all HI-shock devices. To have this valuable information at your fingertips, call your General Electric Sales Engineer today. Or, mail the coupon below. Industry Control Department, Salem, Virginia.

*Progress Is Our Most Important Product*

**GENERAL  ELECTRIC**

## SEND TODAY FOR FREE CATALOG



General Electric Co., Section C785-15  
Schenectady 5, New York

Please send me a copy of the Navy Control Components catalog, GEA-6798, with descriptions, specifications, and pricing data on the complete line.

Name

Company

Address

City  State

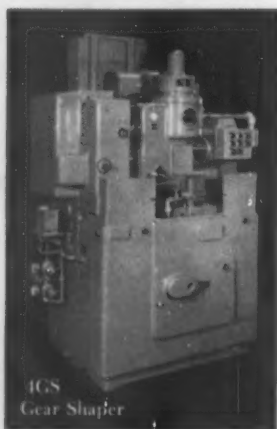


## INVOLUTE GEARS



## NON-INVOLUTE PARTS

# FELLOWS GEAR SHAPERS DO DOUBLE DUTY



4GS  
Gear Shaper

Fellows Gear Shapers are not limited to the production of gears alone. They are valuable production machines ideal for the manufacture of many types of parts, of both involute and non-involute form.

As gear shapers, they provide high production rates in the manufacture of internal and external spur and helical gears. As general purpose production machines, they also make possible the economical production of irregularly shaped parts . . . in many cases doing in one simple operation what would require several operations using conventional shop tools.

Your Fellows representative will gladly give you the facts on how the complete Fellows line of production and inspection equipment helps increase production and cut costs. Ask him, or write direct.

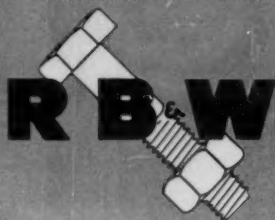
THE FELLOWS GEAR SHAPER COMPANY 78 River Street, Springfield, Vermont, U.S.A.

Branch Offices: 1048 North Woodward Ave., Royal Oak, Mich.  
150 West Pleasant Ave., Maywood, N.J.  
5835 West North Avenue, Chicago 39  
6214 West Manchester Ave., Los Angeles 45

THE  
PRECISION  
LINE

*Fellows*

*Gear Production Equipment*



# FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



## Technical-ities

By Fred E. Graves

### Why cap screws instead of studs?

Many types of products once fastened with studs are today assembled with cap screws. Why the change in preference?

Studs show certain advantages in large diameters and in high temperature applications. But when it comes to smaller sizes used in tapped holes, designers and production people have found more advantages in cap screws.

#### ASSEMBLY FACTORS

In fastener selection for a given application, you have to consider production and assembly as well as joint strength.

Obviously, studs require two wrenchings (first stud, then nut). Also, there's a more expensive close tolerance tapping job, since a stud takes an interference fit to stay tight and not withdraw when nut is backed off.

Cap screws require only a clearance fit. Used in a tapped casting, they can be repeatedly inserted and unscrewed without damage to threads.

#### HOW NOT TO USE STUDS

Studs are not meant to serve as dowels to locate and line up for fastening. To line up numerous studs and bring two pieces together raises assembly cost. Use dowel pins for alignment and use cap screws for fastening to achieve greater economy.

## Screw develops high thread tension . . . and stays locked in place



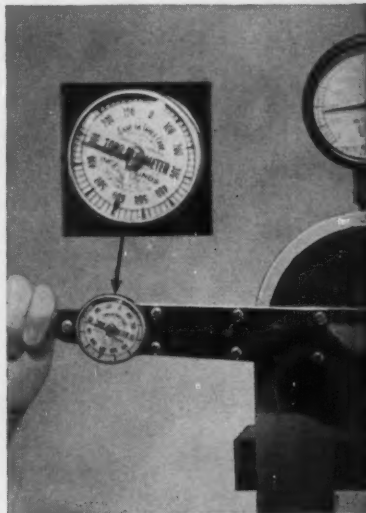
RB&W TENSILOCK screw, despite the friction of the toothed flange, develops 4000 pounds tension with on-torque of 240 inch-pounds.

Here is a locking fastener where the on-torque effort not only *anchors* the screw but also develops high preloading, or residual tension.

Like high tensile cap screws, RB&W's TENSILOCK® screws also give a high thread tension to torque ratio. But there's one important difference. The TENSILOCK fasteners lock with *teeth* as well as high residual tension.

#### RATCHET-LIKE LOCKING

Carburized teeth on flange of this one-piece fastener are so angled as to afford easy torquing. They bite into the seating surface when fastener is fully tightened. A circular groove in the flange increases flexing action and enables flange to



An off-torque of 330 inch-pounds fails to break loose the grip of the teeth. Tension is maintained by TENSILOCK screw.

maintain pressure on the imbedded teeth. To *loosen* a tightened TENSILOCK fastener thus takes much more effort than the on-torque. And it can be reused with little loss of this holding power.

#### FRICTION STOPS SLIPPAGE

The full clamping force exerted by these fasteners prevents slippage of the fastened members where lateral movement is possible because of large or eccentric holes. The positive gripping enables them to stay tight even under conditions of severe vibration or cyclic temperature fluctuations. RB&W TENSILOCK nuts also available. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

\*Trademark Pat. applied for

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.



# NEW! DUAL TORQUE-LOCKING AND POSITIONING DEVICE

**REV-LOK eliminates feedback torque,  
provides two-directional positioning, drive,  
over-running and backstopping**

**NOW!** You can have positive and instantaneous stopping of feedback (reverse) torque—it will never reach the driving equipment. For, the complement of sprags in this new Formsprag device is divided into two opposing sets that: instantly stops feedback from either direction, assures equalized radial loading, evenly distributes wear for longer life, and provides multi-contact surfaces for greater holding strength when high feedback torque occurs.

When the device is mounted with the outer race in a fixed position, feedback is stopped by wedging of sprags between output member and I.D. of fixed outer race—feedback never reaches the input shaft. Yet, this new design permits free rotation and transmission of high driving torque in either direction from input to output shaft. Current catalog models are available in ratings up to 30,000 lbs/in. and with bore diameters to 2½".

When used as a two-directional over-running clutch, output shaft member is mechanically secured against rotation and outer race then becomes the output member. A slight right or left rotation of input shaft disengages either set of sprags and determines direction of drive, over-running and backstopping.

This versatile device can also be used for two-speed drive and reversing applications. By connecting a low-speed reversible motor to outer race and a high-speed motor to input shaft member, driving torque can be transmitted at two speeds or reversed.

Smallest standard Rev-Lok sizes (¾" and 1¼" shaft diameters, 96 lbs/in. output and holding capacity) have the following additional features: mounting flange on outer race, end-to-end or coaxial drive, completely enclosed and permanently lubricated, economical sleeve bearings and roller type contacts.

Rev-Lok devices not only drive, position, over-run and backstop in two directions, but they also provide automatic, instantaneous and positive prevention of feedback from driven equipment to power source. They are compact, have greater torque capacity for their size and weight and permit higher over-running speeds than any similar device. Formsprag technical paper provides further details on operation and features, send for your free copy.

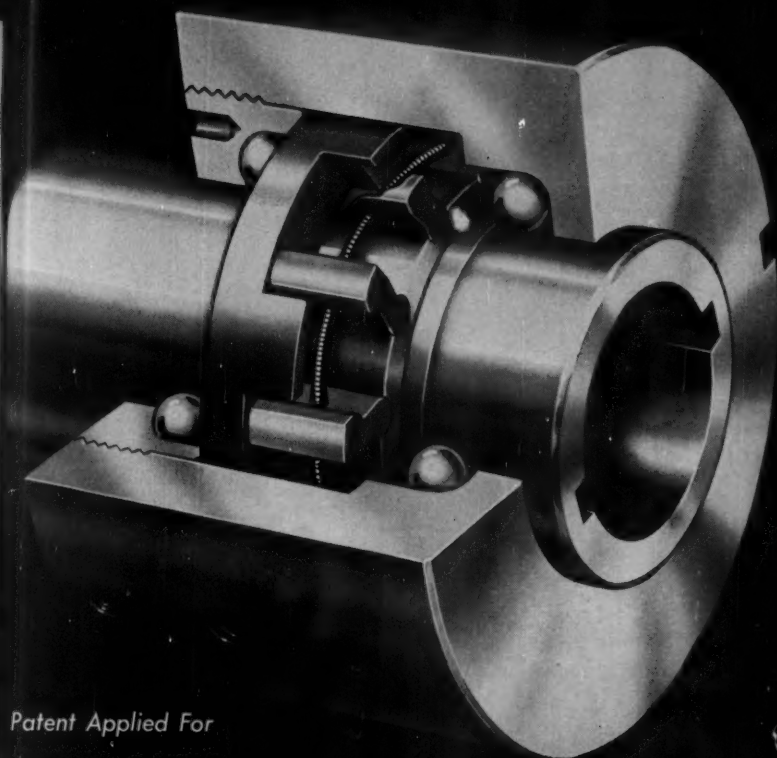
FORMSPRAG COMPANY, 23603 Hoover Road, Dept. 105R, Warren (Detroit), Michigan  
Distributors in Principal Cities.



## FORMSPRAG COMPANY

Precision Power Transmission Products

## Two-Speed Drive and Reverse

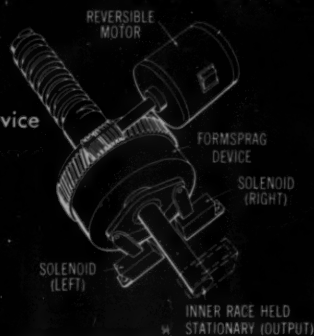


Patent Applied For



Anti-Shock Device

## Position Device

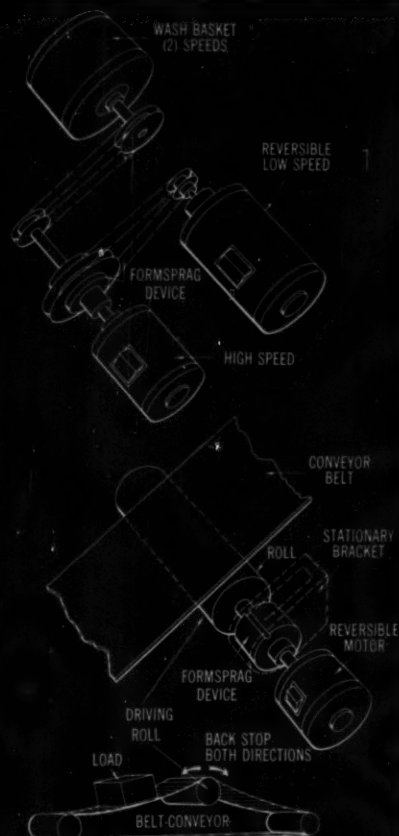


SOLENOID (LEFT)

FORMSPRAG DEVICE

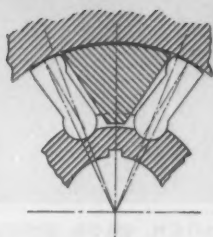
SOLENOID (RIGHT)

INNER RACE HELD STATIONARY (OUTPUT)



Two-Direction Conveyor

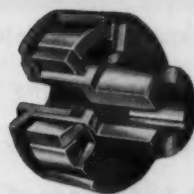
BECAUSE there is a complement of sprags arranged in opposing pairs, there is always a multiple number of contact surfaces engaging the outer race when feedback or backstopping conditions are present. This provides equalized radial loading and strong holding torque against even unusually heavy feedback.



The entire complement of sprags, which is a part of the output member assembly, rotates at driving speed while outer race remains stationary. Thus, sprags are in light contact with the outer race and are always in position to pick up the feedback load at constantly changing points on the outer race. This design feature assures longer life through even distribution of wear over entire surface of outer race. With sprags in constant contact with outer race, any independent movement of output shaft causes instantaneous locking of sprags—there is no backlash on output shaft.

## RAWSON Centrifugal Clutches

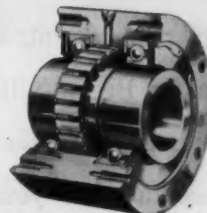
No-Load Motor Starts,  
Cushioned Starting of  
High-Inertia Loads,  
Overload Protection.



## OTHER FORMSPRAG PRODUCTS

## FORMSPRAG Over-Running Clutches

For Every  
Over-Running,  
Indexing &  
Backstopping  
Application



**DESIGN**

**SAFE, DURABLE**

**FLEXIBILITY INTO**

**YOUR LINES with**

***CHIKSAN***

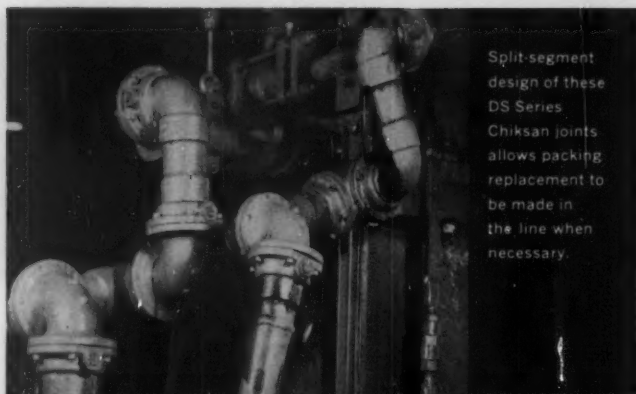
**SWIVEL**

**JOINTS**

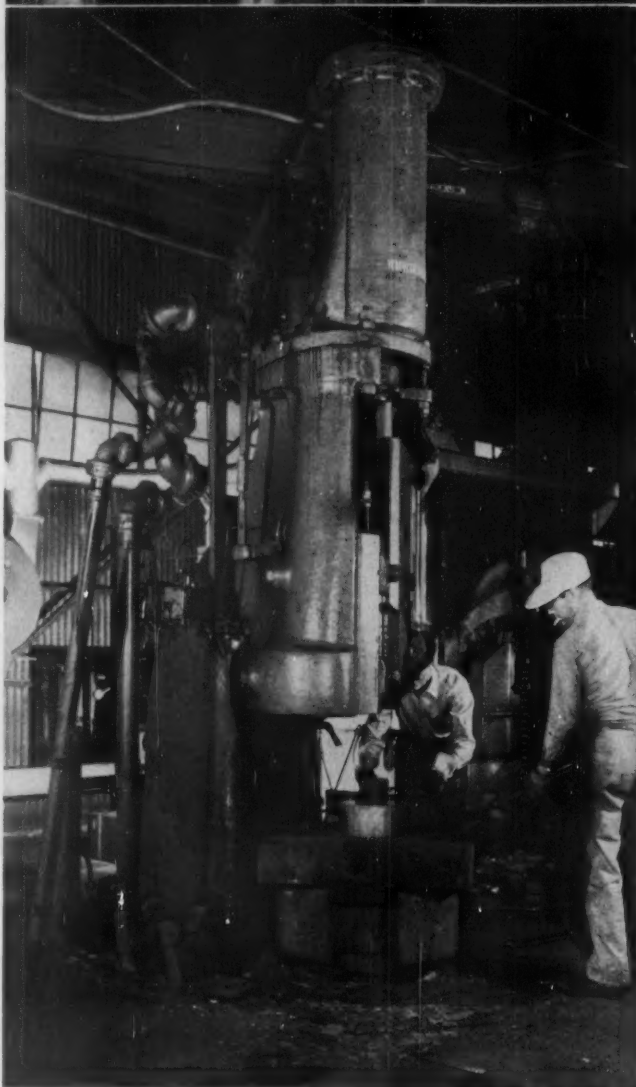
Whenever you apply Chiksan swivel joints, you get a line that lasts longer and reduces maintenance costs for years to come.

Flexing in predetermined arcs, Chiksan joints eliminate common causes of line failure due to tight bends or torsional fatigue. Wherever certain designs require wide hose loops, Chiksan joints permit shorter, more compact lines. In fact, wherever fluid or air lines require flexibility, Chiksan swivel joints can provide a direct and lasting benefit.

Chiksan joints are available from stock in a wide range of materials, temperatures and pressures, to meet practically every design requirement. Write Chiksan Company, Brea, California, today for a catalog and the name of the representative in your area.



Split-segment design of these DS Series Chiksan joints allows packing replacement to be made in the line when necessary.



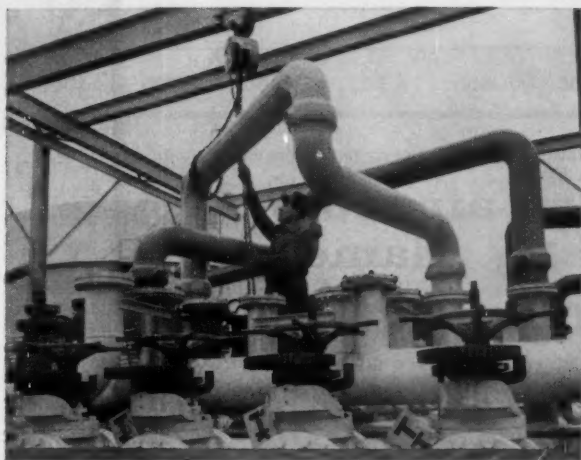
**SHOCK, HIGH PRESSURE STEAM DOESN'T FAZE THESE CHIKSAN JOINTS**—A 2000 pound dropforge with high pressure steam sets up a rough set of service conditions. These Chiksan swivel joints replaced flexible metal tubing which was going out in two and three weeks. Joints have been in service for over five months and customer reports good service to date, expects years more.

**SEND FOR YOUR COPY OF THIS COMPREHENSIVE AND INFORMATIVE SWIVEL JOINT CATALOG.**

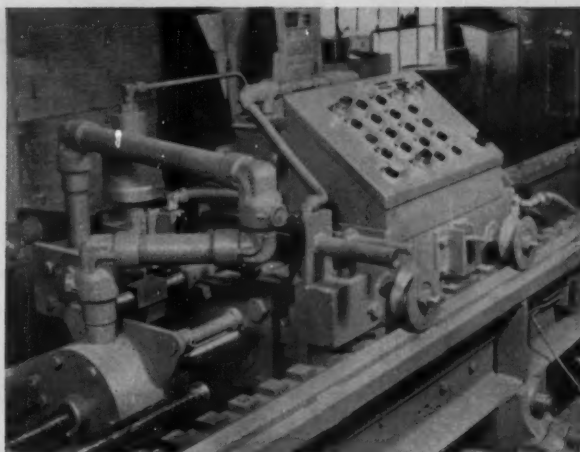




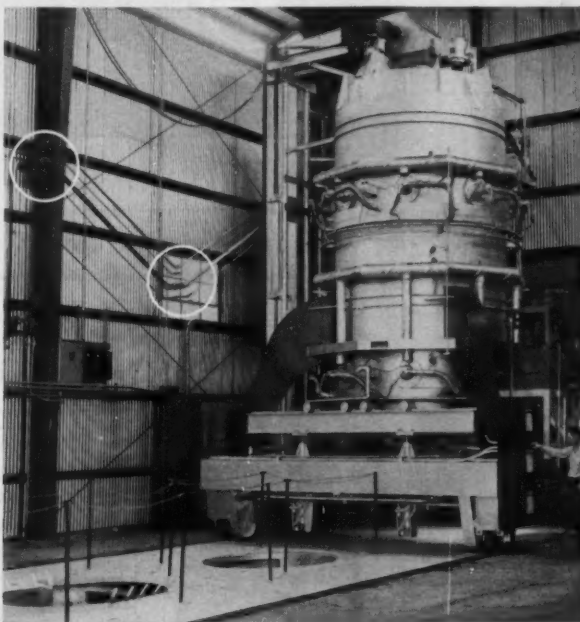
**FLEXIBLE CHEMICAL LINES? CHIKSAN HAS THE ANSWER**—Providing needed safety for a loading arm to handle sulfuric acid (as this Chiksan joint is doing) or most any chemical is an everyday occurrence with Chiksan joints. Over 2000 different types, styles and sizes in a variety of temperature and pressure ratings are available for your design needs.



**SWIVEL JOINTED JUMPER SYSTEM SOLVES MANIFOLD PROBLEMS**—Moving large quantities of differing liquids from barge to storage tanks posed a problem. A closed system wasn't practical because of contamination due to leakage or accidental opening of a valve. Use of a Chiksan swivel jointed jumper system provided a solution that eliminated cross contamination.



**RUPTURE PROOF LINES FOR HIGH PRESSURE HYDROTESTING**—Critical lines take on a new measure of safety with these flexible steel swivel joints. In service on a pipe testing machine, these lines receive up to 1000 pounds of pressure and more every five seconds as lengths of new pipe move through the testing machine. Only occasional service is required to keep these joints in top working condition.



**CONSTANT FLOW CHARACTERISTICS ALLOW PRECISE CONTROL**—Heat treating furnaces require exacting temperature control. Previous experience with flexible hose indicated too much variation in flow characteristics. By using swivel joints and metal piping, company engineers were able to design a supply line system that insured desired control.

#60-54



**CHIKSAN**

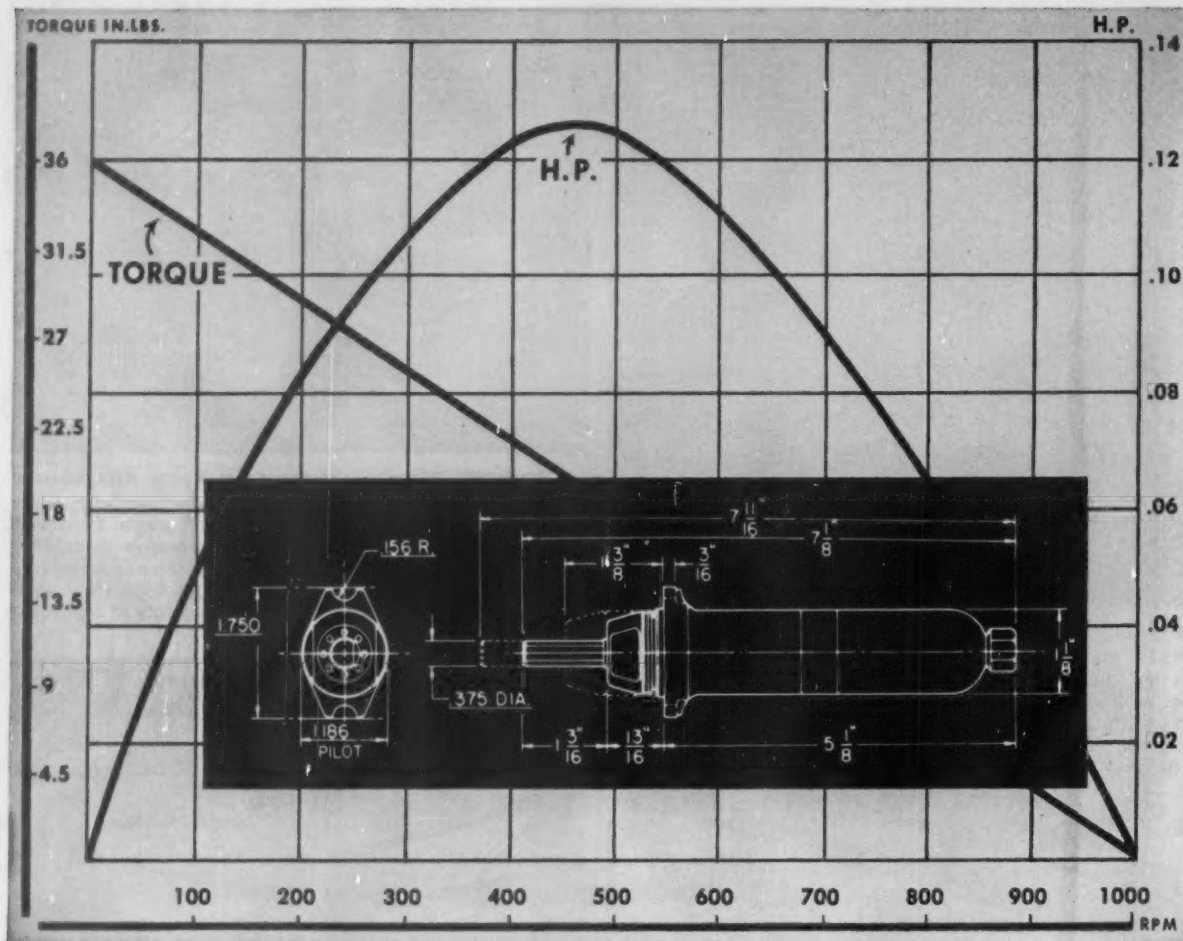
A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

COMPANY • 330 NORTH BREA BLVD., BREA, CALIFORNIA

*Please send me a copy of your latest catalog.*

Name \_\_\_\_\_ Company \_\_\_\_\_  
 Title \_\_\_\_\_ Address \_\_\_\_\_  
 City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_





Power curve for this air motor shows 36-in.-lb. torque at low speed . . . max. power development of  $\frac{1}{8}$  hp.

## Compact rotary air motor packs $\frac{1}{8}$ hp in $1\frac{1}{8}$ " diameter



### WHEREVER IN THE WORLD

the products you design are put to work, your customers will find a convenient Gardner-Denver office with ample parts stocks on hand, and manned by factory-trained service specialists. At Gardner-Denver there's no substitute for men—our 100-year philosophy of growth.

Here's a compact, fractional hp rotary vane air motor, designed by Gardner-Denver for small hp needs that require heavy-duty service.

Ideally suited for close quarters and portable applications, it weighs less than a pound . . . develops  $\frac{1}{8}$  hp with stall torque up to 36 in.-lb. . . . measures only  $7\frac{1}{8}$ " long x  $1\frac{1}{8}$ " body diameter.

This Gardner-Denver air motor also offers variable speed-torque control . . . positive, instantaneous response . . . continuous operation . . . no spark hazard . . . can't burn out.

Three basic speeds are available: 20,000, 5000 and 1000 rpm. Simple plate-mounting with two cap screws makes it easy to adapt the motor to any setup. It's designed to be flange-mounted, locating from a  $1\frac{1}{16}$ " diameter pilot and clamped with two  $\frac{1}{4}$ " screws. Either continuous or intermittent-duty applications are practical.

Other rotary air motors are available in sizes up to 1.5 hp, with piston motors available to 16 hp. Put air power to work in *your* design. Contact your nearby Gardner-Denver representative for complete information or write for Bulletin 71-21.



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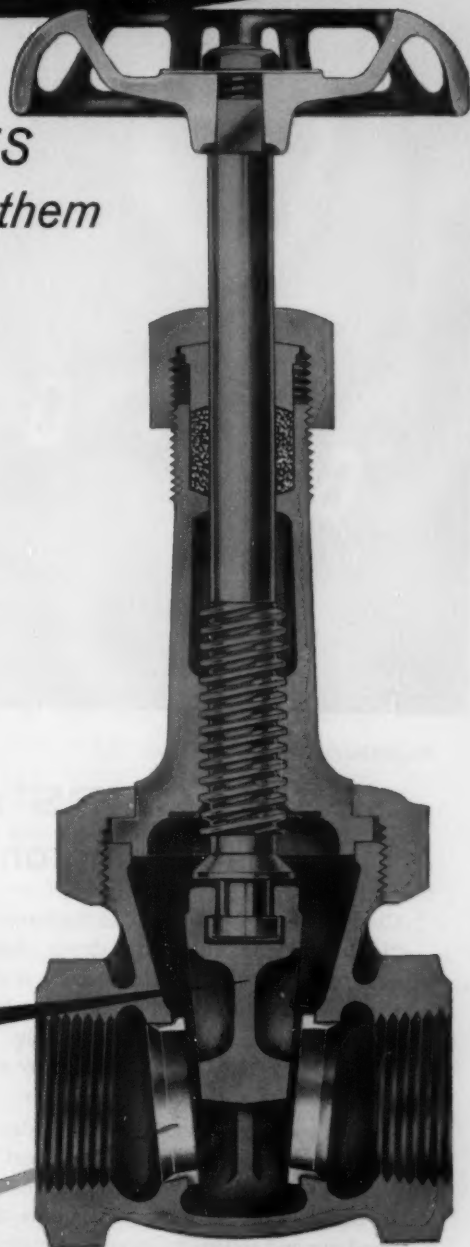
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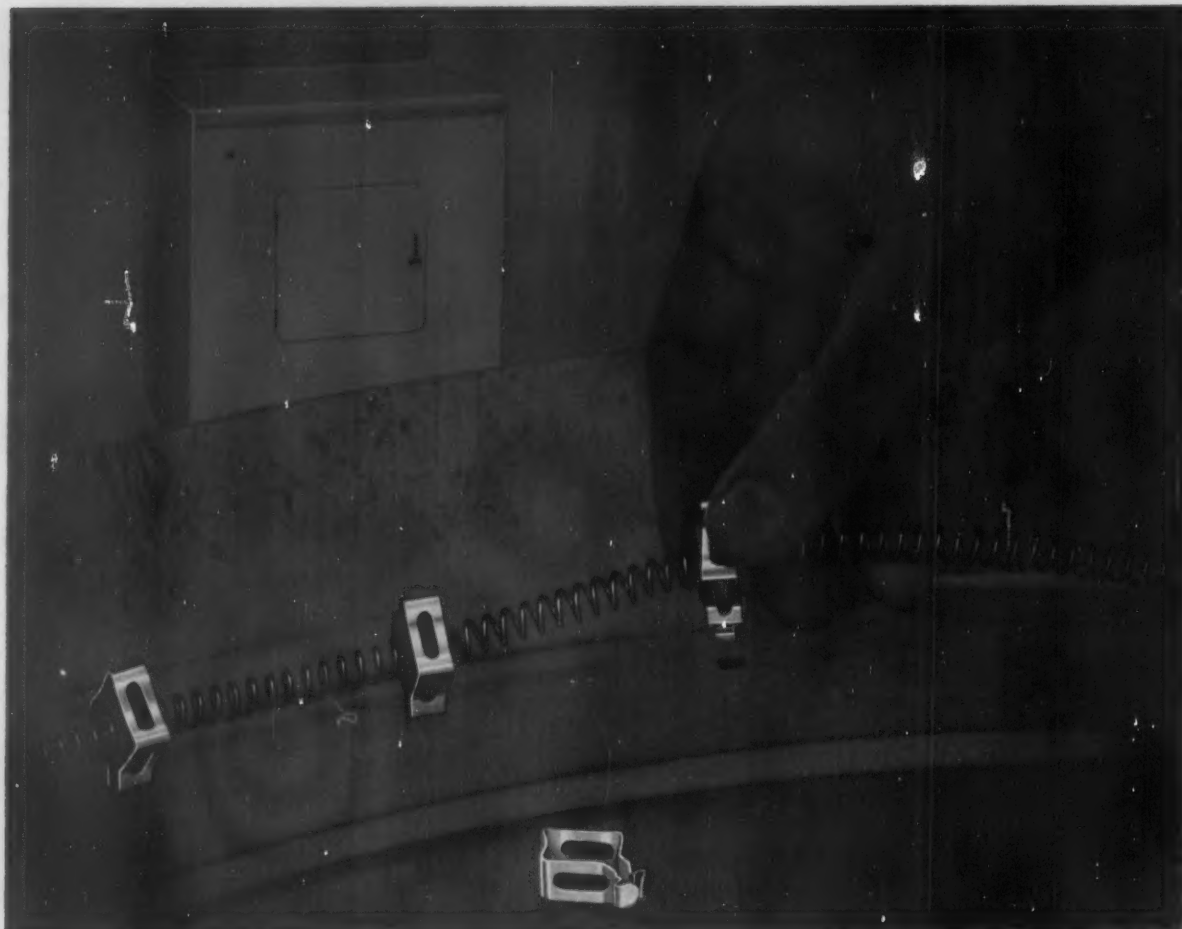
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August 18, 1960



## Environment for Creativity

**E**NVIRONMENTAL testing of new equipment and components is taken for granted these days. Peak performance under any conceivable conditions of climate, dirt, shock, vibration, or what have you, can't be left to chance. It must be designed in.

Unlike hardware, man has limited adaptability to environment. True, what man can do under stress or incentive is often little short of miraculous. But for day-in, day-out high human performance, the environment must be adapted to the man.

In engineering offices and laboratories all over the country we have seen space layouts and furnishings for working engineers ranging all the way from mansions to slums, figuratively speaking.

Plush surroundings, of course, do not automatically insure top-notch engineering creativity. There must be challenges and intangible satisfactions too.

But a good engineering department layout must satisfy basic human environment needs such as are outlined in Bob Murdick's article in this issue. Such surroundings can go a long way toward eliminating distractions that interfere with efficiency, and can contribute significantly toward high morale.

Then it is possible to concentrate on the challenges that develop true creativity.

*Colin Carmichael*

EDITOR





**How to go about**

# **Planning the**

**ROBERT G. MURDICK**

Dept. of Management Engineering  
Rensselaer Polytechnic Institute  
Troy, N. Y.

**Survey existing  
arrangements**

**Analyze needs**

**Plan new layout**

**Evaluate alternatives**

**Implement plans**

**Adjust new  
arrangements**

# Engineering Office

**P**LANNING the engineering office requires evaluation of many factors pertaining to present conditions, and calculated consideration of future conditions. Besides the total space required, thought must be given to the layout of each person's work area with respect to itself and its relationship with others. Over-all appearance, including color scheme, must be planned to provide a functional and attractive working environment. Whether engineering-office planning is continual or occasional, the job is best done in logical steps.

## Preliminary Survey

The survey phase is one of gathering information. The survey includes estimates of future growth or contraction. An organization chart, a roster, and present floor area occupancy should be obtained. The planned organization at the end of about six months, one year, and two years must be estimated by the manager of engineering. A physical survey should be taken to check on office and desk locations, obstructions, electrical outlets, ventilation, lighting, and the condition of partitions, walls,

ceiling, and paint. The office planner should discuss with each manager in the engineering organization his ideas and wishes with respect to office location and size for himself and his personnel. This procedure does not mean that the planner will adopt all the ideas of these managers, but the managers must be given an opportunity to recognize basic problems and conflicts in the use of space.

## Analysis

The planner can post the survey statistics on a chart such as Fig. 1. Totals of area—present, proposed at present, and projected for the future—are calculated. Next, the planner assures that each manager, consultant, and special case is given the floor area to which his position entitles him. Space left over is divided among the remainder of the people. Square feet per person, for this remainder, is a critical figure. If it is insufficient, either the managers and consultants must yield space from their offices, or more office space must be obtained for the whole engineering organization.

If the planner finds that space will be crowded,

[illegible]

he should contact the staff planner for the whole plant to obtain figures on the density of occupancy of other components. With these figures, he can usually make a fair case for more space. He can emphasize that working conditions for the line people—the producers—should not suffer in support of indirect labor. If the engineering planner has a really strong case, he can bring the manager of engineering into the negotiation. Continual tactful pressure by the engineering planner on the top staff man, by means of reviews, analyses, and proposals, will often accomplish the end result.

## Planning Principles

At the end of the analysis phase, the planner knows how much space he is going to get or what possibilities are available to him. The next step is to make one or two over-all plans, detail them, and get cost estimates. This step is the most difficult part of office planning because there are dozens of combinations of partition arrangements, interior layouts, and grouping relationships. A good procedure is to start with a scale drawing of the present layout. Then,

1. Establish general areas for each component organization.
2. Examine each area to see if the assigned component can be fitted into existing offices, with private offices as required.
3. If step 2 is a poor fit, it may be possible to interchange positions of some of the organizations.

4. When the best fit is obtained, or if the present layouts are completely unsatisfactory, sketch in colored pencil where new partitions should go.
5. Make sure that each component has approximately the same area per man after the managers are given their due. If not, reassign some floor area accordingly.
6. Review the proposed office areas with the managers, showing them how they are all being treated fairly. At the same time, obtain their views on where they would like their people located in the offices with respect to each other for proper grouping on the job.
7. Draw the detailed layouts.

The engineering-space planner can help the engineering manager to evaluate the need for private offices by reviewing four main justifications: Job responsibility, kind of work requiring concentration, work of a confidential nature relating to the business or to personnel records, and status symbol as an inducement for hard-to-get specialists.

An area of 45 sq ft per engineer, laid out in the most ideally shaped office, is the minimum for the bulk of the working force.

The planner most often encounters the two types of areas shown in Fig. 2. The long area with the main corridor down the center lends itself well to economical layouts. There is plenty of natural light and natural circulation of air. The barn-type of area must usually be laid out with interior offices because a corridor down the center makes the offices too big and too deep. In both types of offices, window size and column spacing are important factors. Both affect the location of permanent

## Planning the Engineering Office

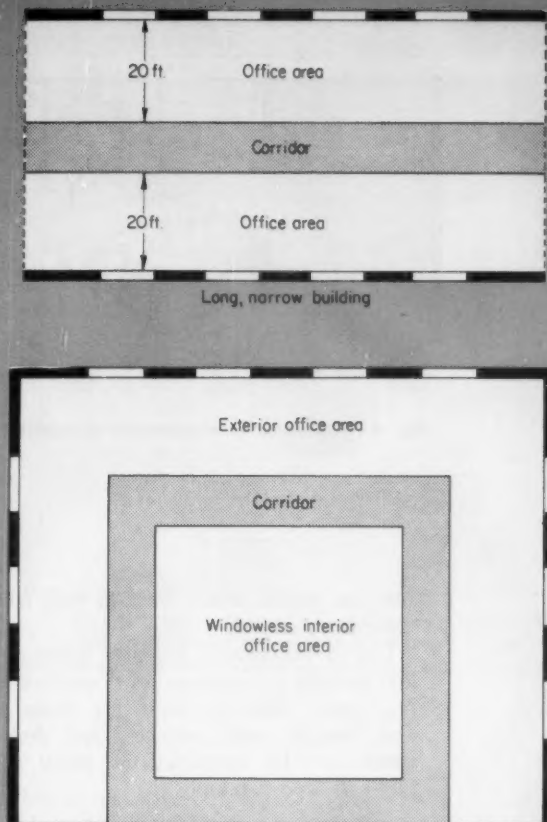


Fig. 2—Most common shapes of areas apportioned to engineering departments.

or semipermanent walls.

These additional points should be checked:

1. Do desks face the same way except where two employees are working together?
2. Are desks (work areas) facing the same or opposite directions separated by at least  $2\frac{1}{2}$  ft?
3. Are the aisles designed to minimize traffic through the office?
4. Are the main aisles 5 ft wide and secondary aisles 3 ft wide?
5. Are desks placed so that employees do not face directly into the outside light?
6. Are files and heavy equipment against walls or columns?
7. Are individuals who receive frequent visitors, or who often leave and return to the office, located near the doors?
8. Are files centralized in one location or placed near the user in such a fashion as not to reduce the lighting for others adjacent?
9. Is the secretary located centrally with respect to the group she serves?

### Layout Mechanics

Techniques for office layout are fewer and simpler than for factory and manufacturing layouts,

particularly where installations such as washrooms and main corridors are already established. Three commonly used techniques are: Template drawing on translucent  $\frac{1}{4}$ -in. grid paper, cross-section matte foil layouts, and steel cross-section sheets with magnetic scale models.

In the first method, a scale template of office furniture is used. Quarter-inch grid paper can be selected so that the cross-section lines will or will not be produced in same-size photocopies of the layout. Each office with doorways, obstructions, and columns is outlined on the grid. Desk positions are drawn in lightly because frequent erasures are necessary. The final layout may be drawn with a special orange-colored backing to obtain better reproduction. This method is economical and relatively rapid.

Cross-section matte foil layouts are made on translucent or transparent film. Opaque silhouettes of the furniture are attached to the foil by means of double-coated pressure-sensitive tape. Partitions and columns are laid out from a spool of special pressure-sensitive tape in assorted widths. Reproduction is by direct photocopy process. Special supplies must be stocked although the cross-section sheets and silhouettes may be used over and over.

In the third technique, a rigid metal sheet (usu-



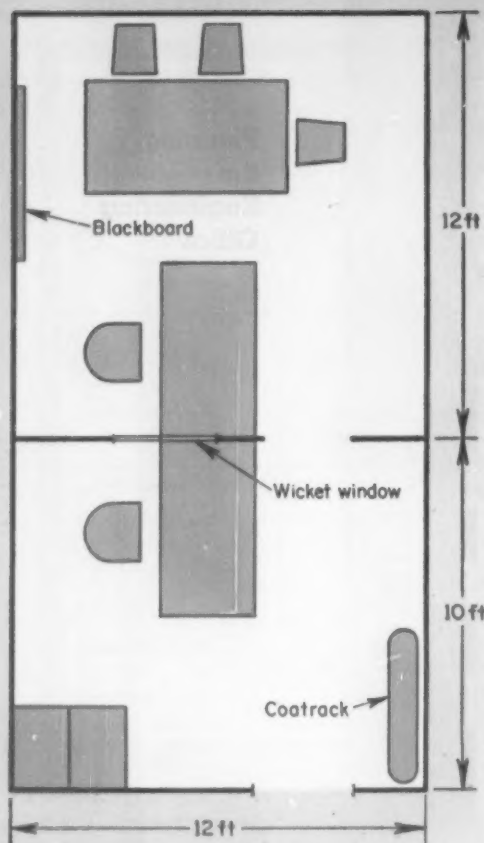


Fig. 3—Space and furniture for an engineering manager.

ally green in color with white cross-section lines) is employed. Models of the furniture with small magnets attached to the back are moved into various trial positions. Walls are outlined by chalk or tape. The final layout may be traced onto paper or photographed. This method allows rapid experimentation with different arrangements.

### Space Allocations

Arguments about status aside, planners are expected to find space for executives in proportion to their rank and importance. In addition, space must be found for conferences and special engineering projects.

**Managers' Private Offices:** In the case of offices approximately 22 ft deep, running along each side of a main corridor, it is possible to develop standard furnishing for various grades of engineering personnel. For managers reporting to the engineering manager, ceiling-height walls should be used. Fig. 3 is a typical layout. An office size ranging from 9 by 12 ft to 12 by 16 ft or 108 to 192 sq ft might be appropriate. Fig. 3 shows the 3 by 5 ft desk and table. A space of 5 by 5 ft is required for a man and his desk of this size so that it usually



Fig. 4—Representative arrangement of modular furniture.

does not matter which way his desk faces as far as space is concerned.

Use of commercial modular furniture is increasing because it increases work surface per unit of floor area. Modular units are desks, cabinets of desk height, work surfaces, and desk high files which can be assembled in many combinations. Fig. 4 shows an example.

**The "Bull Pen":** When a group of 10 to 20 engineers must work closely together on a project or in some function, the practice has been to assemble them in a large room commonly called a "bull pen." The advantage of locating the engineers within sight and sound of each other is offset by the disadvantages of the additional noise, traffic, and sometimes the "packing factor" or low floor area per man. An optimum size room which offers much flexibility in layout but permits high packing is 22 ft deep by 30 ft long, Fig. 5.

Sometimes it is desirable to have a bull pen even when there is plenty of space. In this case, the planner should keep in mind certain combinations of arrangements such as the 14 by 5 ft block for desk-table-desk or the desk-table-bookcase-file block, Fig. 6.

The development of functional partitions, quickly erected and rearranged, has contributed greatly to improvement of engineering working conditions. These partitions come in varying heights, 54 in. being very common, Fig. 7. The top 18 to 20 in. may be either clear or frosted glass. In addition, a blackboard or corkboard may be substituted for any of the glass panels. A rule of thumb estimate of the cost of these partitions, plus installation, is \$25 per linear foot and \$50 for a door added to the doorways. Sliding wicket windows are about \$50 extra and special arrangements must be made if the user wishes them set in at the height of 30 in. New partitions for an entire office can be erected in one to three days or removed in a matter of hours.

When making layouts for functional partitioning, the engineering planner should be sure to specify the interior dimensions of the offices to be

## Planning the Engineering Office

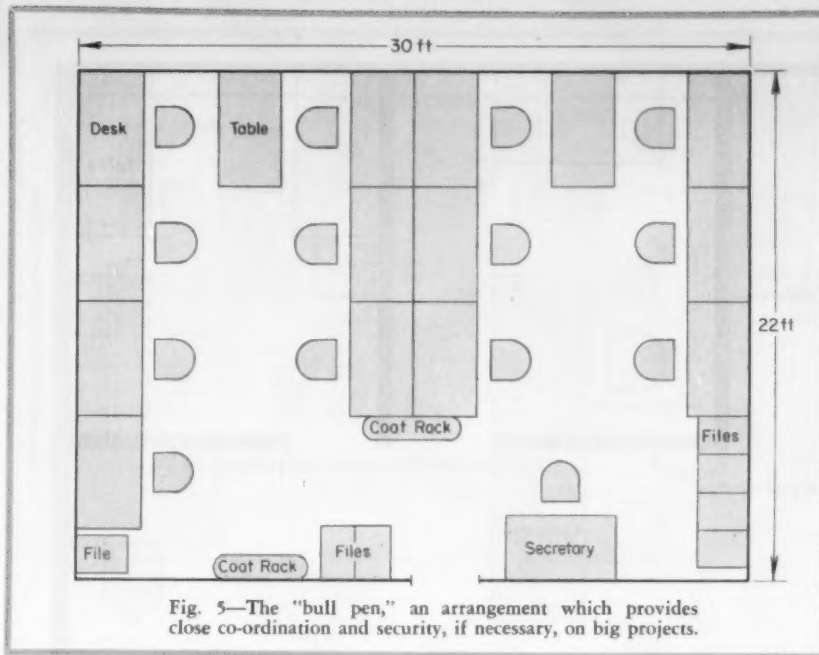


Fig. 5—The "bull pen," an arrangement which provides close co-ordination and security, if necessary, on big projects.

formed. Partitions themselves are approximately two inches thick. Functional partitions with frosted glass in the upper 18 in. have little adverse effect in the light and air circulation. While such partitions do little to reduce the noise level, they are of tremendous aid in reducing distractions. Private offices formed with functional partitions also are excellent means of acknowledging the status of engineering group leaders and specialists for a low outlay of space and money.

**Drafting Rooms:** In some companies, the draftsmen, working closely with the designers, are scattered around in the engineering groups. When there is a shortage of floor area, or for other reasons, the draftsmen may be located together in one large room. An example of the latter type of layout is shown in Fig. 8.

**Conference Rooms:** Any size or shape area may be used for a conference room as long as it satisfies its prime function of providing a degree of privacy and quiet. Large conference rooms may have over-size rectangular tables or specially constructed tables, Fig. 9.

### Working Environment

The use of factory gray for all walls is rapidly vanishing. Two-tone offices in pastels of blue, green and gray, bright yellow on north walls, and sand and buff colors are appearing more frequently. Contrasting trim of black or a dark color around the base of the walls is practical. Ceilings of white or cream acoustical tile are also popular. The planner should seek professional help in the selection of colors.

Another easy-to-forget item is the location of electrical outlets. The final layout should show the locations of all outlets required for electric typewriters, calculating machines, and desk lamps.

Illumination in most offices is supplied by overhead fluorescent lighting. Lines of fluorescent lights are spaced about 4 ft. Some areas near partitions or in the corners of offices may not have adequate lighting. File cabinets or other furniture often contribute to this condition. What is the minimum standard of illumination? Some companies consider 25 footcandles as the minimum, but engineers doing concentrated paper work most of the day tend to find that such a low level produces fatigue.

In one study, research asked 82 adults to select,

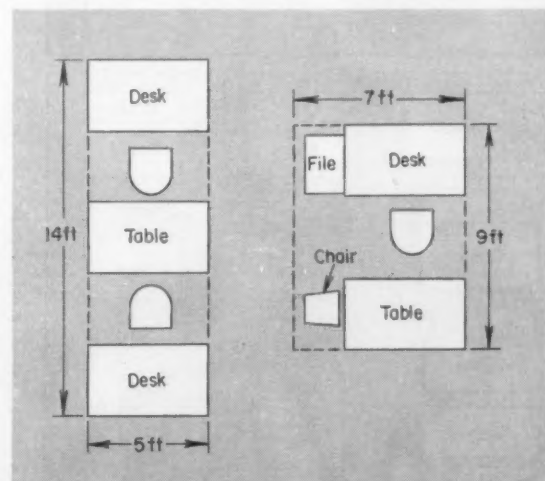


Fig. 6—Compound modules of office furniture.

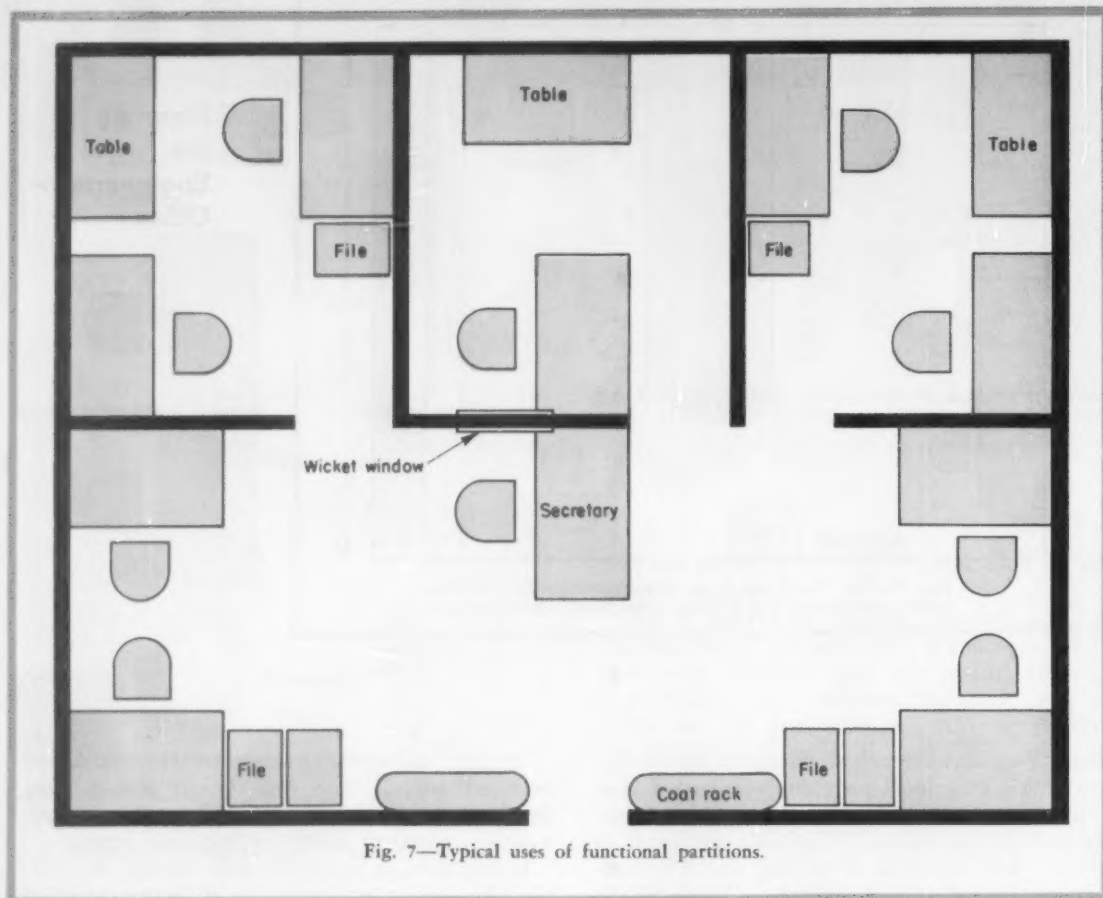


Fig. 7—Typical uses of functional partitions.

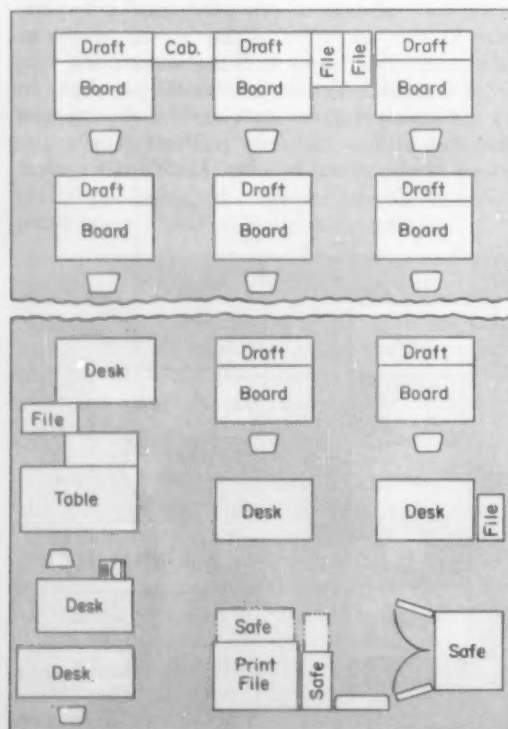


Fig. 8—Typical layout of a drafting room.

after actual trial, the intensity of illumination considered ideal for reading black print on white paper over long periods. Nearly three in four preferred 50 footcandles or more. Too much illumination, like too little, produces strain and fatigue. The planner should check work stations if there is any question regarding illumination.

Heat, relative humidity, and circulation of air are factors affecting the output of the worker which must be of concern to the engineering-office planner. If an economic evaluation shows that air conditioning is not desirable, fans in the office may help prevent decreased output on hot summer days.

## Alternatives

Engineering planners may make alternate plans and list advantages of each, but it is the responsibility of the engineering manager to make final evaluation and decision. The engineering manager is advised to consult with his subordinate managers on the use of space. When a plan has been chosen, those concerned should initial it. This may seem trivial, but it can prevent misunderstandings later.

## Moving Day

The final plan should be carried out with minimum disturbance to engineering personnel. Second-

## Planning the Engineering Office

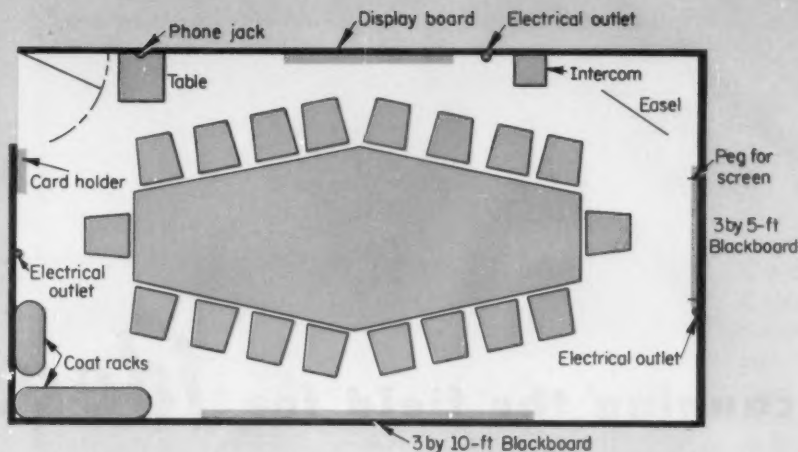


Fig. 9—Hexagonal conference table featuring good visibility.

shift construction is sometimes possible, but premium costs may rule it out. In any case, the work should be done quickly by assigning as many men to the job as can work efficiently at the same time.

Interruption of telephone service should be minimized.

For the actual moving of furniture, the movers must be supplied with the old and the new plans. The actual furniture should be tagged. Drawers of desks and files should be locked and no bottles of ink or other liquid kept in them. Delicate equipment, typewriters, and calculating machines should be moved by people who customarily handle such equipment.

## Final Adjustments

After any large move, adjustments are inevitable. Plans which appear excellent on paper often can be bettered after the new arrangement is actually in use. Unforeseen circumstances may dictate the need for minor adjustments. The planner should make a complete survey after the rearrangement, get all comments and complaints, and work out an adjustment plan for the present or for the future.

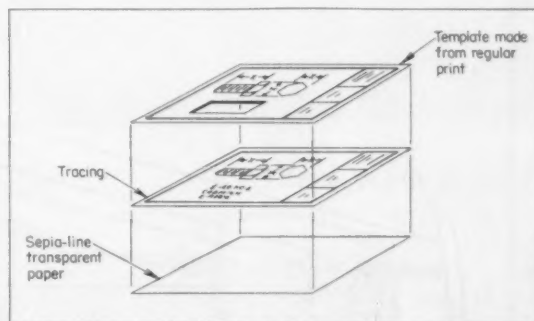


## Tips and Techniques

### Reproduction Prints

Neatness can be improved in making sepia-line transparent reproduction prints by using a masking system rather than resorting to eradication of large areas.

1. A regular print is made from the original tracing. The area to be removed or changed is then cut from the print.
2. The cut-out print is placed over the sepia-line transparent paper and the two sheets are run through the exposure (only) section of the print machine.
3. The tracing is then placed on the sepia-line paper so that the part to be deleted lines up with the exposed emulsion area.
4. Exposure and development are then made in normal manner.

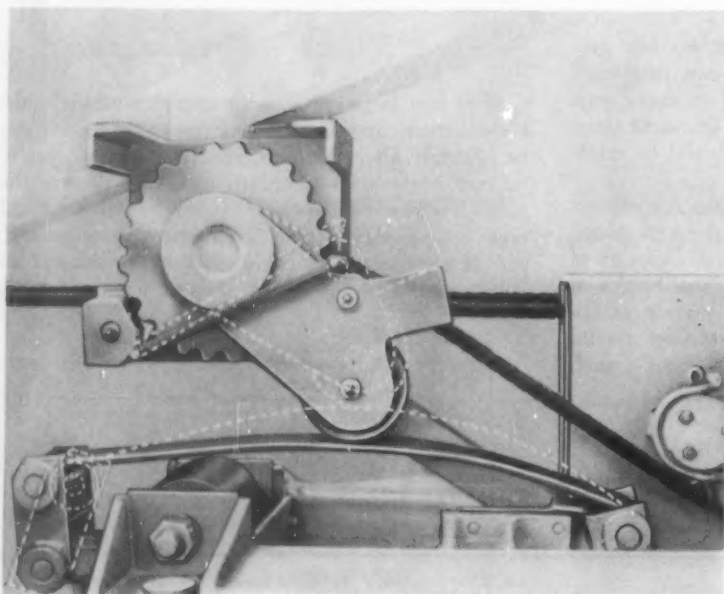


—AL ROMIN, Sunbeam Corp., Chicago, Ill.

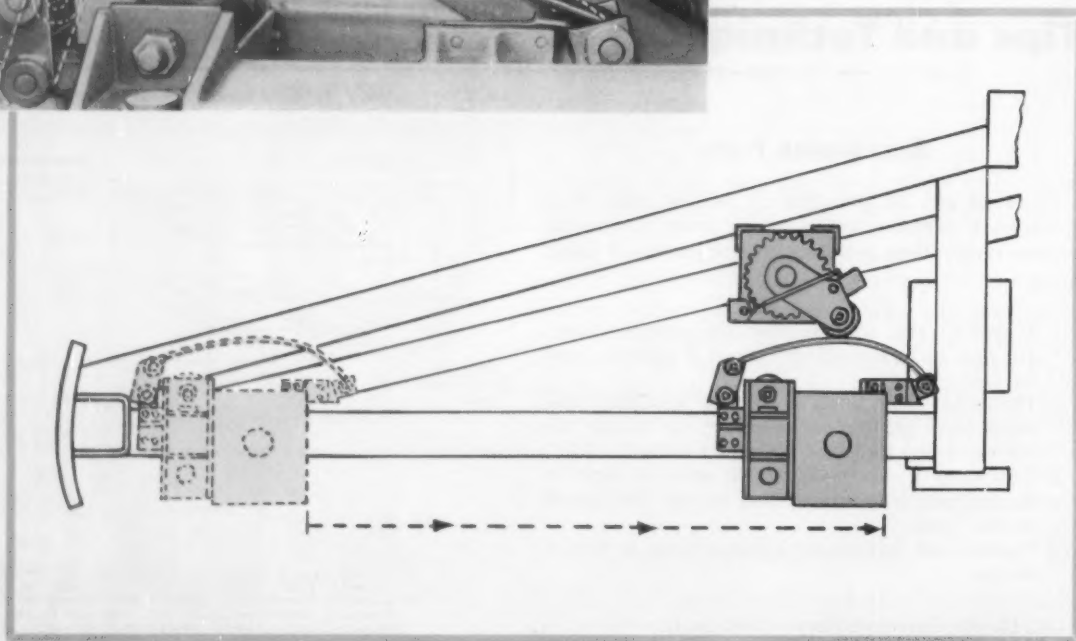
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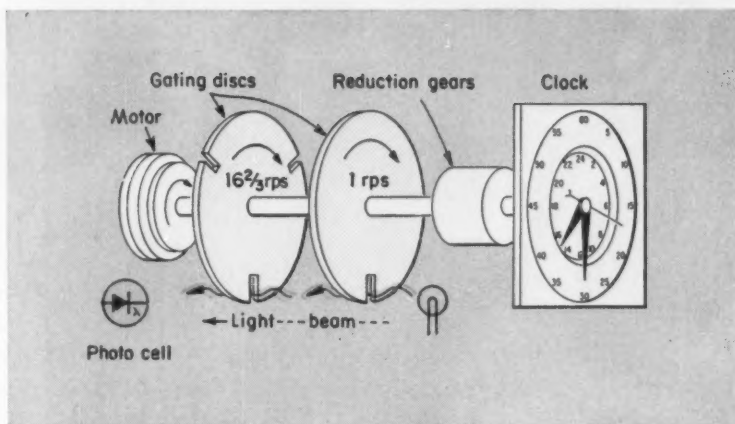


## scanning the field for *ideas*

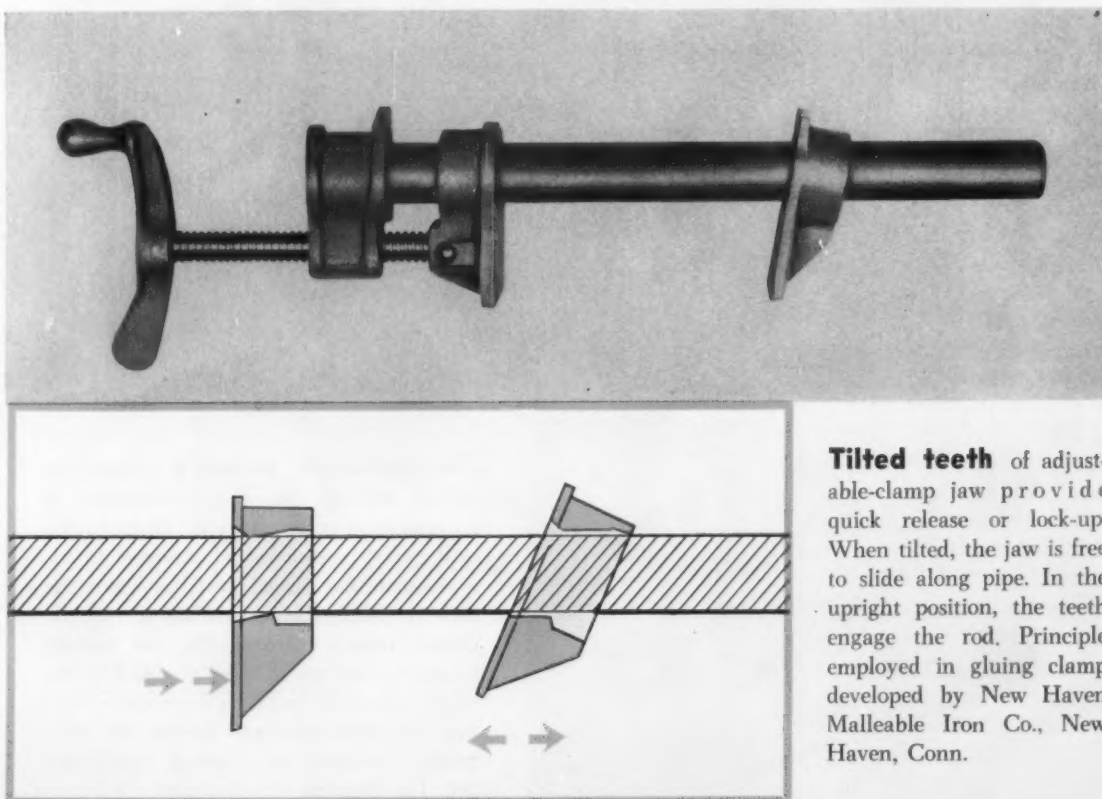


**Resilient cam** yields at preset value to limit torque applied to the follower arm. A leaf-spring arrangement, mounted on a reciprocating machine element, is used to actuate a ratchet-type cable tightener. When the desired tension is obtained, the spring deflects instead of moving the follower. Principle employed in automatic cable tightener reported by Cliff Johnson, LeTourneau-Westinghouse Co., Peoria, Ill.



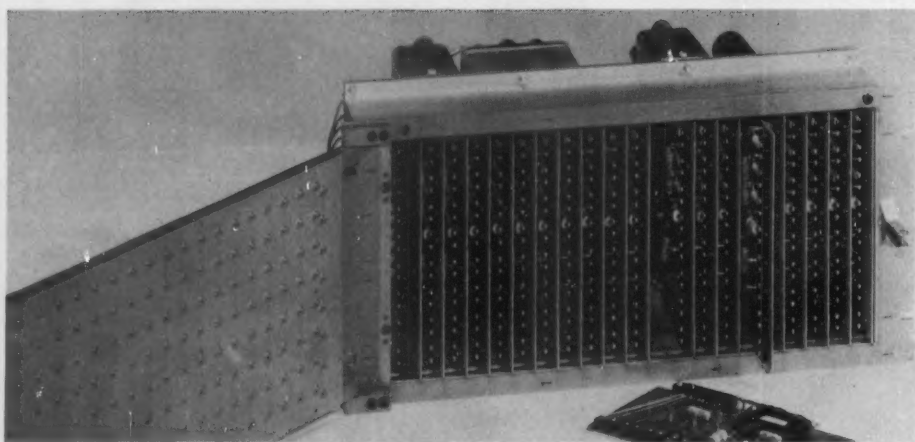
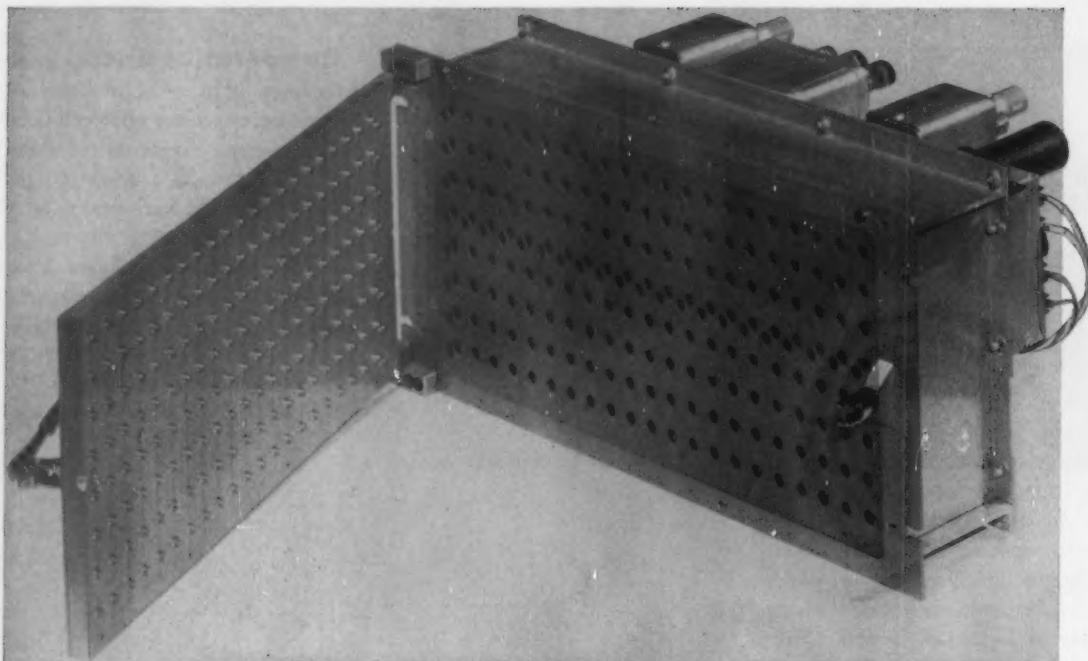


**Co-operative discs** provide flashing light of 1 millisecond duration to actuate photocell once each second. Single-slotted slow-speed disc passes a beam of light for a relatively long period once each second. During this period, one slot of the triple-slotted high-speed disc sweeps past, allowing the light beam to pass for 1 millisecond. Principle employed in frequency divider and clock developed by Hewlett-Packard Co., Palo Alto, Calif.

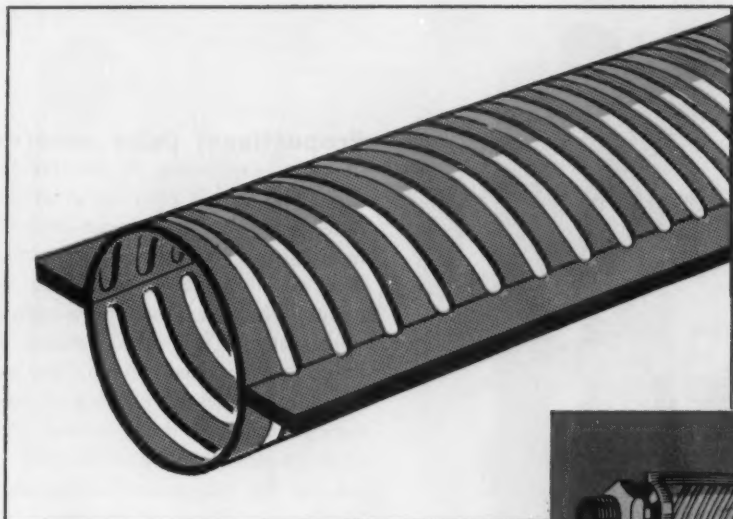


**Tilted teeth** of adjustable-clamp jaw provide quick release or lock-up. When tilted, the jaw is free to slide along pipe. In the upright position, the teeth engage the rod. Principle employed in gluing clamp developed by New Haven Malleable Iron Co., New Haven, Conn.

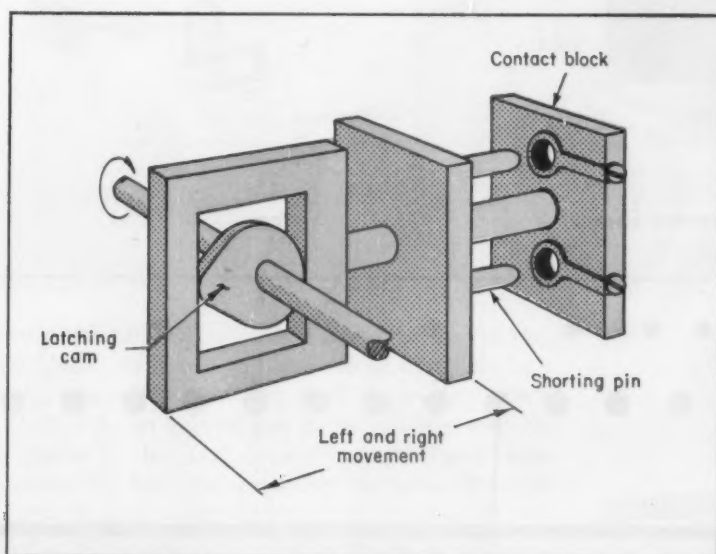
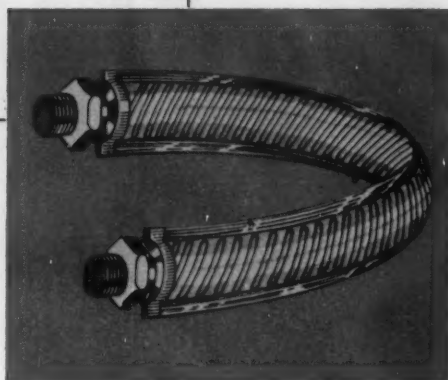
## SCANNING THE FIELD FOR IDEAS



**Punched-card memory** eliminates setting and adjusting of potentiometers in an analog-function generator. Holes in the card permit spring-loaded plungers to actuate matching sealed switches when the door is closed. These switches set up the proper resistor network for the desired functions. Pattern of holes punched in the readily changed card thus determines function. Principle employed in function generator developed by General Computers Inc., Los Angeles.



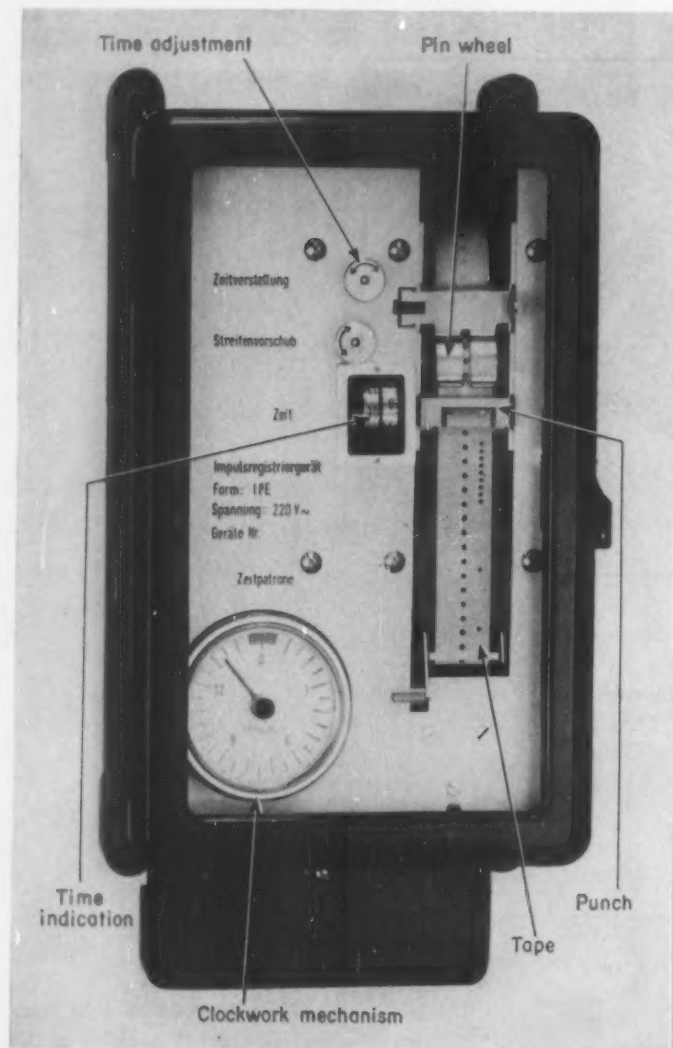
**Single-plane rigidity** of a flexible metal hose is provided by a longitudinal rib on a slotted-metal hose guard. The inner hose may be rubber, plastic, or flexible metal, as required. Principle employed in hose covering developed by Guardflex Metal Hose Inc., Garden City Park, N. Y.



**Shuttle contacts** are mechanically locked in either of the alternate switching positions by a caged cam in a bistable relay. A solenoid and ratchet linkage rotates the camshaft 180 deg each time a current pulse is applied to the solenoid. Principle employed in a latching relay developed by Astromics, Glendale, Calif.

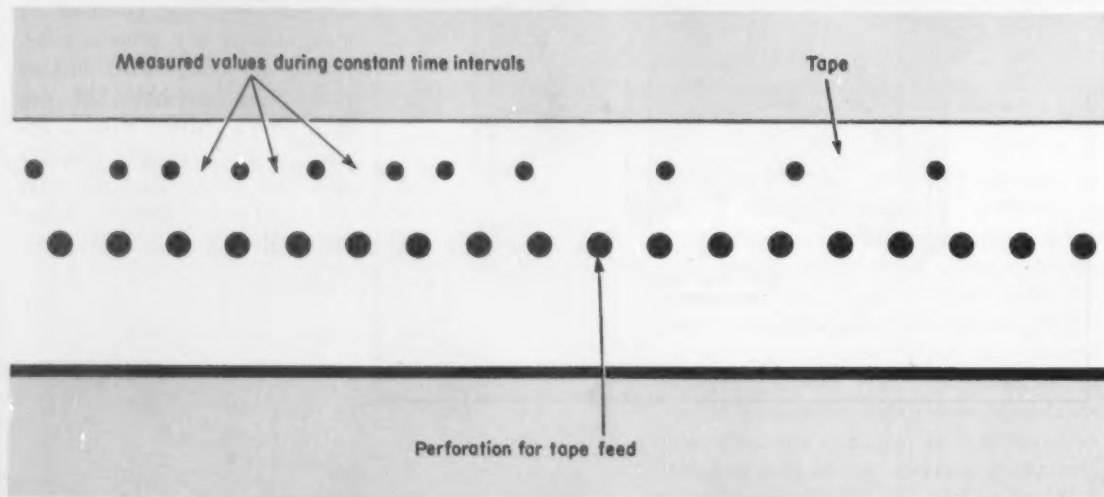
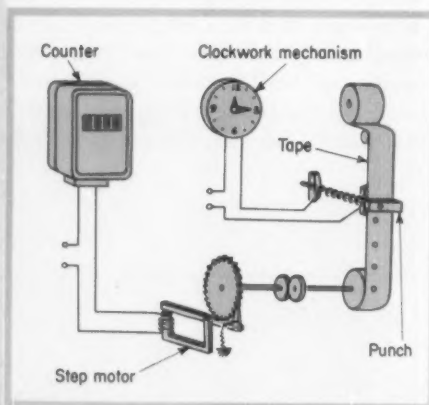


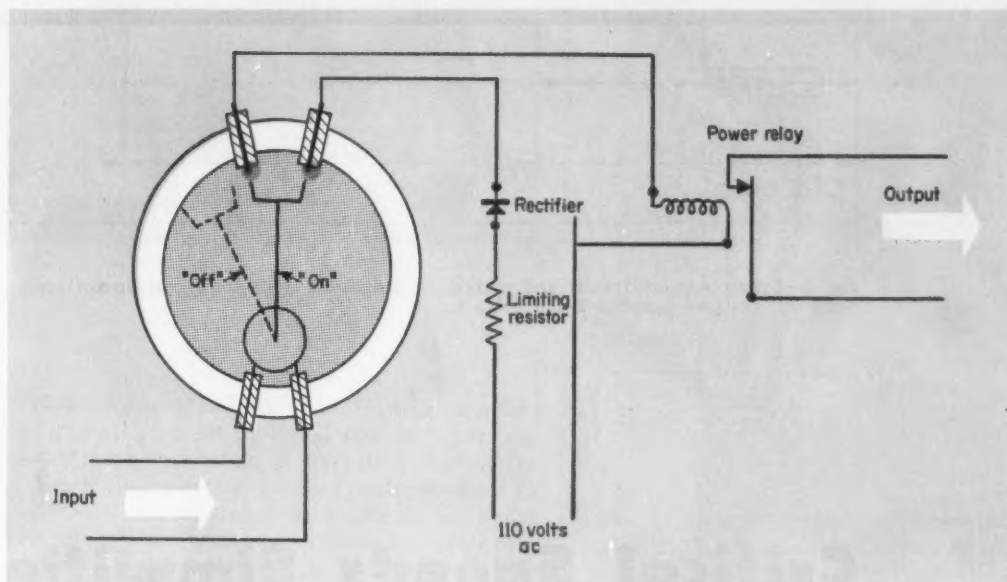
## SCANNING THE FIELD FOR IDEAS



### Proportional pulse recorder

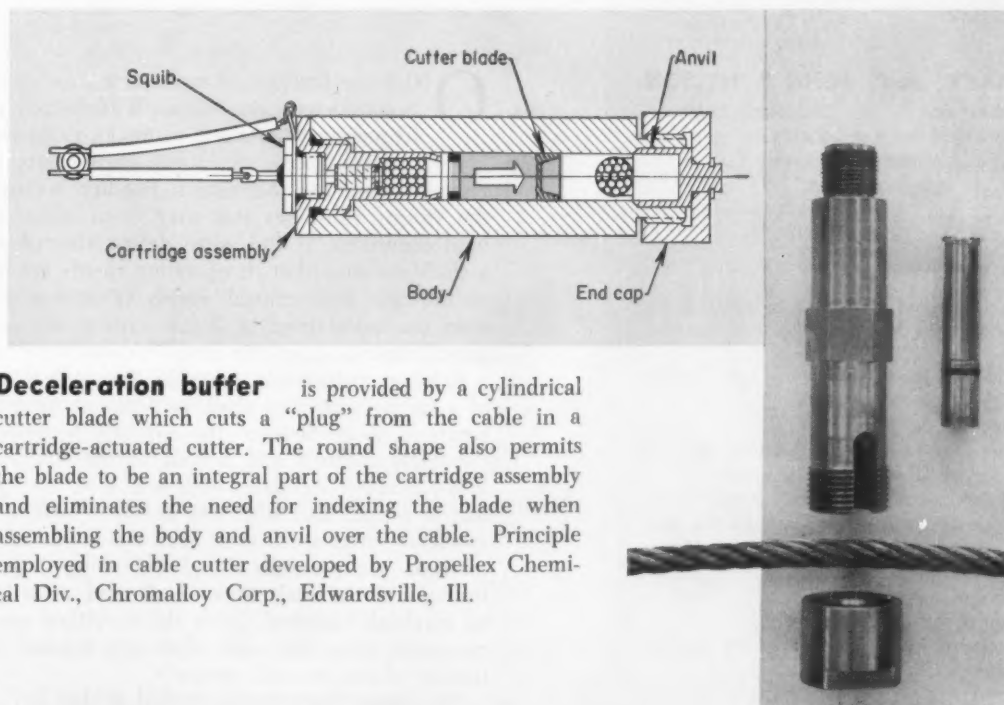
simplifies evaluation of punched-tape data. The tape is punched at uniform time intervals by a timer-controlled mechanism. The variable being measured controls the speed of the tape travel, through the pulse-operated step motor. Thus, the distance between the punched holes in the tape is a measure of the number of pulses during the fixed time interval. Principle employed in data recorder developed by Allgemeine Elektrizitäts-Gesellschaft, Berlin, Germany.





**Gas-surrounded contacts** complete circuit without touching. Only a small current is required to deflect the pointer of a gas-filled microammeter to a position that almost bridges the gap between a pair of station-

ary contacts. The gas surrounding the contacts ionizes and completes the circuit, thus actuating a power relay. Non-touching principle employed in switch developed by Fred Lichtgarn, Northlake, Ill.



**Deceleration buffer** is provided by a cylindrical cutter blade which cuts a "plug" from the cable in a cartridge-actuated cutter. The round shape also permits the blade to be an integral part of the cartridge assembly and eliminates the need for indexing the blade when assembling the body and anvil over the cable. Principle employed in cable cutter developed by Propellex Chemical Div., Chromalloy Corp., Edwardsville, Ill.

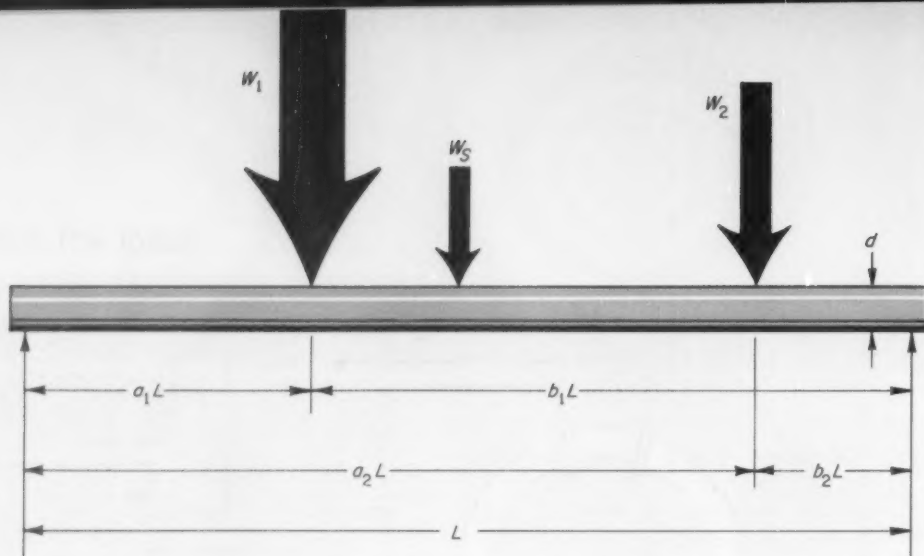


Fig. 1—Simply supported shaft and method of designating position of concentrated loads along it. Compare Equation 2 and Table 1.

## Critical Speeds Simplified

Predicting the critical speeds of shafts by calculations entailing shaft deflections can be involved and time-consuming. Here is a quick method of approximating the first critical speeds of shafts.

**F. F. FERRARY and JOHN E. NELSON**

Technical Consultant      Standards Engineer  
Technical Services Laboratory  
American Machine & Foundry Co.  
Stamford, Conn.

### Nomenclature

- $a$  = Ratio of distance from left bearing to line of action of any concentrated load (as  $W_1$ ) and the total distance
- $b$  = Ratio similar to  $a$  but measured from right bearing; hence  $a + b = 1$
- $d$  = Diameter of shaft, in.
- $E$  = Modulus of elasticity of steel, 29,000,000 psi
- $F$  = Mid-span sum of all equivalent loads, lb
- $F_g$  = Load equivalent at mid-span of shaft weight  $W_s$ , lb
- $F_l$  = Load equivalent at mid-span of concentrated load  $W_1$ , lb
- $L$  = Distance between shaft bearings, in.
- $N$  = Critical speed of system, rpm
- $W_g$  = Total weight of shaft, lb
- $W_1$  = Any concentrated load or weight at any position between supports, lb

ONLY the first critical speed of a rotating shaft is considered here because it is the one most frequently determined in design calculations.

Any critical speed, of course, corresponds to a resonant state and becomes a liability because of the violent vibrations that may occur under resonant conditions. If and when design dimensions of a shaft are such that its operating speeds are likely to coincide with critical speeds of higher order, then the calculations of higher critical speeds are also necessary.

Existing methods to solve for the critical speed of a simply supported shaft with one or more concentrated loads between the supports becomes increasingly difficult and tedious as the number of loads increase. Actually, with one load, the problem is simple. But with two or more loads a tremendous increase in work occurs because existing methods are generally based on using static deflections of the shaft under each load as outlined by Rayleigh's method. With the simplified method presented here, time and effort are reduced to a fraction of that required normally.

The theory behind this method is that any con-

**Table 1—Load Position Parameters**

Load Position Ratio, $a$	Parameter $16 (a b)^2$
0.05 or 0.95 .....	0.035
0.10 0.90 .....	0.129
0.15 0.85 .....	0.259
0.20 0.80 .....	0.410
0.25 0.75 .....	0.560
0.30 0.70 .....	0.706
0.35 0.65 .....	0.824
0.40 0.60 .....	0.922
0.45 0.55 .....	0.976
0.50 .....	1.000

centrated load, located anywhere between two simple supports, can be converted into an equivalent concentrated load acting at mid-span. The weight of the shaft itself may also be converted into an equivalent concentrated load acting at mid-span. The sum of these equivalent concentrated loads substituted into a simple formula results in the first critical speed of the system.

**Conditions:** Fig. 1 illustrates a shaft of weight  $W_s$  subjected to two concentrated loads  $W_1$  and  $W_2$ . These conditions are assumed:

1. The shaft may be either horizontal or vertical.
2. The shaft is steel, of constant diameter, and uniform in stiffness.
3. The shaft is freely supported at the ends by the bearings.
4. The bearings are excluded from the system.

**Equations:** From Timoshenko\*

$$F_s = \frac{17}{35} W_s \quad (1)$$

and

$$F_1 = 16 W_1 (a_1 b_1)^2 \quad (2)$$

When several loads are involved, the equivalent sum,  $F$ , at mid-span of the shaft weight and all the concentrated loads is

$$F = F_s + F_1 + F_2 + \dots \quad (3)$$

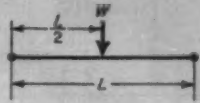
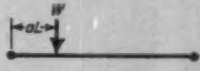
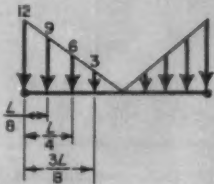
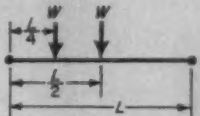
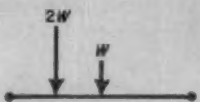
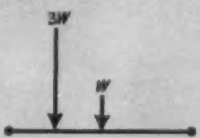
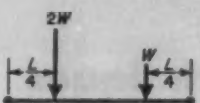
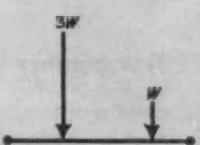
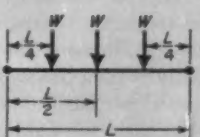

Finally, the critical speed of the system is

$$N = \frac{1,550,000 d^2}{L \sqrt{F L}} \quad (4)$$

Table 1 gives parameters in terms of ratio  $a$  for

\*S. Timoshenko—*Vibration Problems in Engineering*, 2nd edition, D. Van Nostrand Co. Inc., pp. 85-86.

**Table 2—Variations from Rayleigh's Method**

Load Diagram	Nature of Load	Variation†
	1. One load at mid-span	0
	2. One load anywhere	0
	3. Two equal loads symmetrical about mid-span	See load diagram
	4. Two equal loads as shown	-2.0
	5. Two unequal loads as shown (same location as 4.)	-2.1
	6. Two unequal loads as shown (same location as 4.)	-1.6
	7. Two unequal loads as shown	-5.0
	8. Two unequal loads as shown (same location as 7.)	-4.1
	9. Three equal loads as shown	-3.6
	10. Three equal loads as shown	-2.0

†In per cent. A minus sign indicates that the speed calculated by this method is less than that determined by Rayleigh's method.



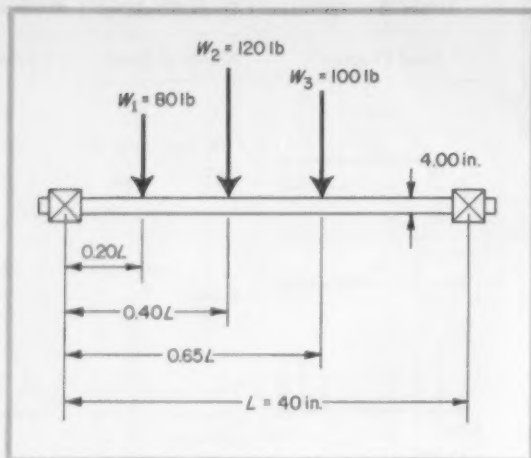


Fig. 2—Specification of three concentrated loads for the shaft of the example.

the ready solution of Equation 2.

**Example:** Determine the critical speed of the shaft of Fig. 2. Steps in the calculations are:

1. Find the weight of the shaft. Steel shafting of 4-in. diam weighs 42.73 lb per ft.  $W_s = 42.73$  (40/12) = 142.29 lb.

2. Find the equivalent weight of shaft ( $F_s$ ) considered as acting as a concentrated load at mid-span. Using Equation 1,  $F_s = 17$  (142.29)/35 = 69 lb.

3. Find the load equivalents at mid-span of each of the concentrated loads. From Table 2,  $F_1 = 0.410$   $W_1 = 32.8$  lb;  $F_2 = 0.922$   $W_2 = 110.6$  lb;  $F_3$

$$= 0.824 W_3 = 82.4 \text{ lb.}$$

4. Find the total equivalent load acting at mid-span. Using Equation 3,  $F = 69 + 32.8 + 110.6 + 82.4 = 294.8$  lb.

5. Solve for the critical speed  $N$  with Equation 4.

$$N = \frac{1,550,000 (4)^2}{40 \sqrt{294.8 (40)}} \\ = 5735 \text{ rpm}$$

**Correction Factors:** The foregoing answer is not precisely the same as the critical speed found by the application of Rayleigh's method. It may be regarded as a good approximation.

Inasmuch as test critical speeds of shafts do not agree always with those predicted by calculations, either method of calculation is really an approximation. Table 2 shows the variations in the calculated results by the two methods for some common types of loading.

If Rayleigh's method is taken as the best criterion for design calculations, then the results obtained by the present short-cut can be adjusted accordingly.

The 5735 rpm of the foregoing problem can be adjusted in this way: The actual load pattern falls between diagrams 9 and 10, Table 2. The line of action of the 120-lb load is one-fifth the distance between midspan and the left bearing.

Actual loads are roughly equal. Subtracting one-fifth the difference between  $-3.6$  and  $-2.0$  from  $-3.6$  gives  $-3.3$  per cent, which may be used as a corrective factor. Thus,  $5735/0.967 = 5930$  rpm, as the more probable critical speed.

## Tips and Techniques

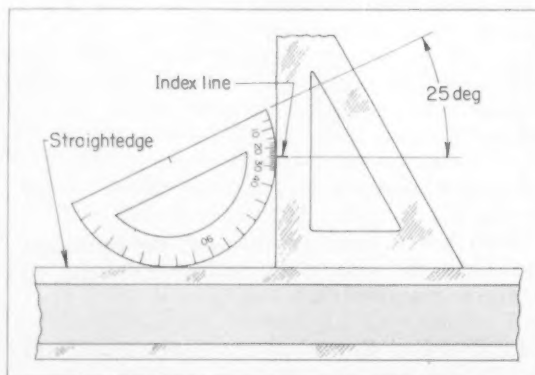
### Renewing Triangle Transparency

Transparency of celluloid drafting triangles and French curves that have discolored or become stained can often be appreciably restored. Mineral spirits or turpentine works well on moderate stains; duplicating-machine fluid on more stubborn ones.

Stains are removed by lightly wiping the surface of the implements with a soft cloth that has been dipped in the liquid. Since the strength of duplicating-machine fluid can vary, it is wise first to make a test run on a triangle of little value.—GLEN F. STILLWELL, Manhattan Beach, Calif.

### Drawing Angles

Accurate angular lines can be made by using a semicircular protractor and triangle as shown in the figure. To adapt the triangle for this use, an index line is scribed on both sides, at a distance from



its base equal to the radius of the protractor.

To draw a line at a given angle through a given point, the desired angle on the protractor is lined up with the mark on the triangle and both pieces are moved as a unit along a straightedge until the base of the protractor is on the given point.—M. W. LOFTUS, Chicago, Ill.

# Techniques for Controlling Pressure in hydraulic systems

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One of the advantages unique to hydraulic actuation is the ability to control force by the control of pressure. In some special applications, minimum as well as maximum pressure must be controlled. There are a variety of methods for accomplishing these objectives. This article details techniques as well as the components and circuits necessary to put them into action.

**M**AXIMUM or minimum forces produced by a hydraulic actuator are controlled by regulation of the hydraulic system pressure. Maximum-pressure control protects the machine structure against overloading. Minimum-pressure control insures the application of adequate forces or torques to do the proposed work and the proper operation of components which depend upon hydraulic pilot pressure.

## ► Maximum Pressure

Maximum system pressure cannot exceed the sum of the internal and external resistances. This principle applies to all the pressure-control devices in the following discussions.

**Pressure-Compensated Control:** The variable-delivery hydraulic pump which has its effective displacement controlled by a hydraulically operated pressure-compensating device is one of the most efficient maximum-pressure control devices available, Fig. 1. In operation, a pressure-compensating de-

vice is set for the maximum pressure desired in the system. While the system pressure is below this setting, the pump operates at full stroke and delivers maximum flow. When the system pressure approaches the maximum-pressure setting, the compensating device reduces the effective displacement and diminishes delivery to the amount required to make up the system leakage.

The power required to drive a hydraulic pump is directly proportional to the product of the system pressure and the fluid flow. Therefore, if operating conditions permit a reduced flow rate, high system pressure can be maintained with relatively low power consumption. This type of pressure-control system is ideal for those applications in which pressure must be maintained to hold a static load for long periods; or, for traverse and feed circuits requiring high volume at low pressure during the first part of the rapid-traverse stroke and low volume during the last or feed portion of the working stroke.

**Variable Orifice Bleedoff:** This system of maximum pressure control, Fig. 2, is used primarily in testing

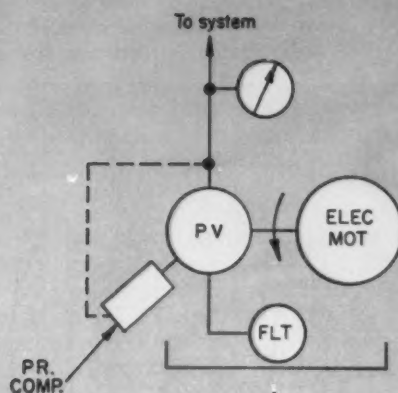


Fig. 1—Pressure-compensated pump.

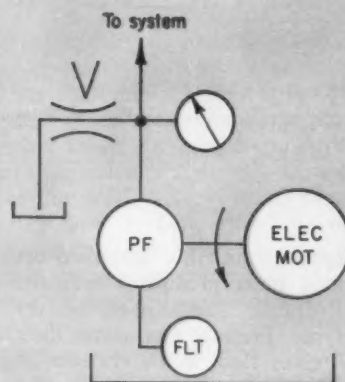


Fig. 2—Variable-orifice bleedoff circuit.

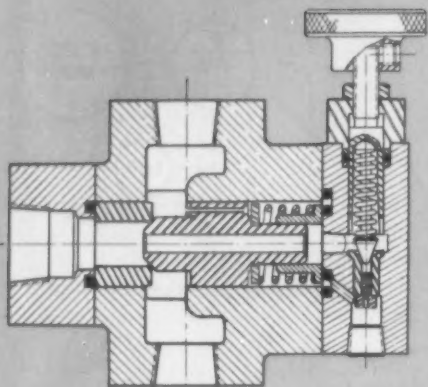


Fig. 3—Pilot-actuated relief valve.

applications. For successful operation, the external load must produce a constant pressure, and the hydraulic pump must be the fixed-displacement type. Pressure drop across the orifice is constant for a given flow, if the viscosity also remains constant. With the orifice or needle valve wide open, all the flow bypasses directly back to the tank with only slight pressure drop across the pressure control. As the variable orifice is closed, pressure drop across

the control increases. For static testing with rotary hydraulic pumps, very constant hydraulic pressures can be maintained with this variable-orifice bleed-off system.

**Relief Valve:** The most commonly used device to limit the maximum pressure in hydraulic systems is the hydraulic relief valve. It is most often used in hydraulic circuits with fixed-displacement pumps. Occasionally, it is used with variable-displacement pumps which are not pressure compensated. Basically, the hydraulic relief valve is a normally closed, two-way valve. If the system pressure remains below the pressure set on the relief valve, the valve remains closed. When the system pressure approaches the relief valve setting, the valve opens to relieve the pressure. As additional oil flows through the relief valve to the tank, the valve opening increases to accommodate the flow without excessive pressure buildup. An ideal relief valve would control the pressure so accurately that there would be no difference between the system pressure with minimum flow through the relief valve and system pressure with maximum flow through the relief valve.

The direct spring-operated relief valve which includes a spring-loaded ball poppet or spool is not an ideal relief valve. The valve must move axially against spring force to increase the orifice area at higher flow rates. Since the force required to compress a spring is directly proportional to its deflection, the direct spring-loaded relief valve produces higher pressure buildup when larger flows are relieved. The per cent of pressure increase due to this increased deflection of the spring is called the cracking range. Cracking pressure of a relief valve is the pressure at which the valve starts to open.

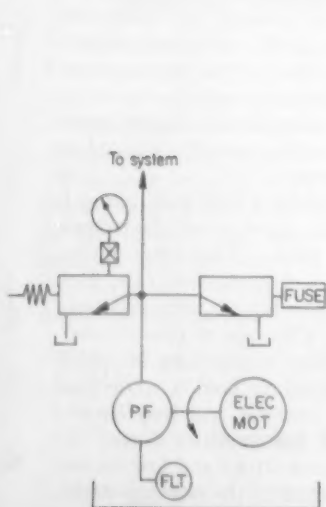


Fig. 4—Hydraulic fuse.

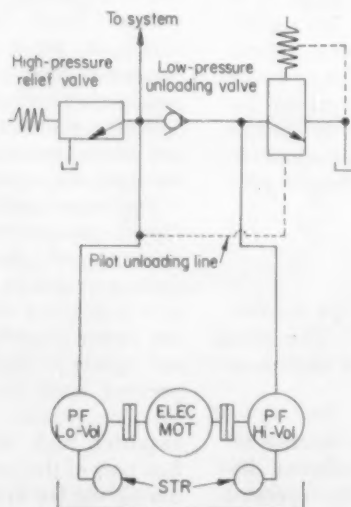


Fig. 5—Unloading valve.

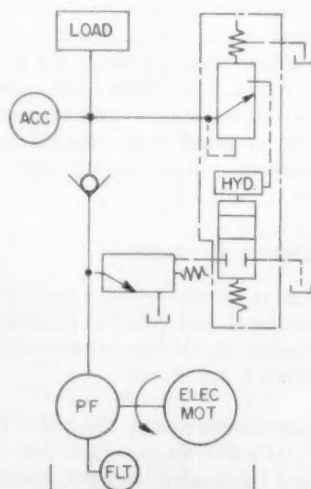


Fig. 6—Hydraulic accumulator.

**Piloted Relief Valve:** Low cracking ranges can be obtained with this valve, Fig. 3. A pressure-actuated pilot valve controls the pressure balance that positions the main valve. When the pilot valve is closed, an orifice in the main valve permits pressure to build up on the spring side of the main valve. Because the area behind the valve is larger, the resulting force pushes the valve onto its seat. When the pressure-actuated pilot valve is opened, the cavity behind the main valve is vented to the tank. The orifice in the main valve restricts the pressure buildup in the cavity. The resulting unbalanced force opens the main valve, permitting the pump output to flow directly to the tank.

The cracking range of this valve is very narrow. It extends only from the pressure necessary to start the opening of the pilot valve to the pressure necessary to hold the pilot valve open enough so that the annular area around the pilot valve exceeds the area of the orifice in the main valve. A low-rate spring provides adequate force to insure closing of the pilot valve. Therefore, only slight pressure buildup is required to hold the pilot valve fully open.

The capacity of the main valve permits the pump output to flow directly to the tank with very little pressure buildup.

Piloted relief valves may include ports for remote control. Or, they may be connected to a remote pilot valve similar to the pilot of the main relief valve. This arrangement provides remote control of pressure settings up to setting of the pilot of the main relief valve. Solenoid controls can be arranged to permit automatic venting of the pilot valve as well as remote selection of operating pressures.

**Hydraulic Fuse:** Inertia of the moving parts of the relief valve prevents its opening quickly enough to prevent damaging pressure buildups as a result of external shock loads applied to the actuator. If the pressure buildup exceeds 150,000 psi per sec, a hydraulic-fuse assembly, Fig. 4, must be used to prevent damage to the system components. The hydraulic fuse is a frangible disc which ruptures at a definite pressure, thus permitting direct flow to the tank. The hydraulic fuse is selected to provide a rupture limit several hundred psi above the setting of the main valve of the system.

**Unloading Valve:** A normally closed two-way valve controlled by an external pilot signal from some other portion of the hydraulic circuit is used as an unloading valve. A typical application of the unloading valve is shown in Fig. 5. This circuit is known as a hi-lo circuit. Such a combination of a low volume, high-pressure pump and a high volume, low-pressure pump often can be used to replace a single pressure-compensated variable-delivery pump. A hydraulic press is a typical application. Here, the requirements are rapid approach at relatively low pressure, with prolonged holding at high pressure.

The hi-lo circuit can be obtained as a complete pressure-control panel assembly to simplify its installation and maintenance. This assembly consists of a double pump in one housing, plus a pressure-con-

trol panel which includes the relief valve, check valve, and low-pressure unloading valve.

**Hydraulic Accumulator:** Maximum system pressure may also be controlled by an accumulator. This is a device for storing hydraulic energy to be released later upon demand. Small accumulators consist of a shell containing a spring-loaded piston. Pressure in the system forces hydraulic fluid into the piston chamber, compressing the spring. Larger accumulators have a chamber charged with air, nitrogen, or other inert gas. The system hydraulic pressure acts against the piston to compress the gas, thereby storing potential energy.

Nonseparated accumulators consist of cylindrical-shaped vessels which have an enclosed space at the top. This space contains gas under pressure which is compressed by the action of the hydraulic fluid. Pistons or diaphragms are used in separated-type accumulators to separate the hydraulic fluid from the gas under pressure.

Fig. 6 shows an accumulator circuit in which a pilot pressure line controls a hydraulic relay valve which, in turn, vents the main relief valve on the pump-control circuit. When the accumulator pressure reaches the preset value, the relay valve opens and vents the main relief valve pilot directly to tank. This venting causes the relief valve to open. Thus, pump flow is directed back to tank with little restriction. When the accumulator pressure is reduced the relay valve closes the venting port on the relief valve and consequently loads the pump and recharges the accumulator.

Built-in mechanically operated pilot valves can also be used. These valves control loading and unloading of the pump from predetermined positions of the operating piston in the accumulator.

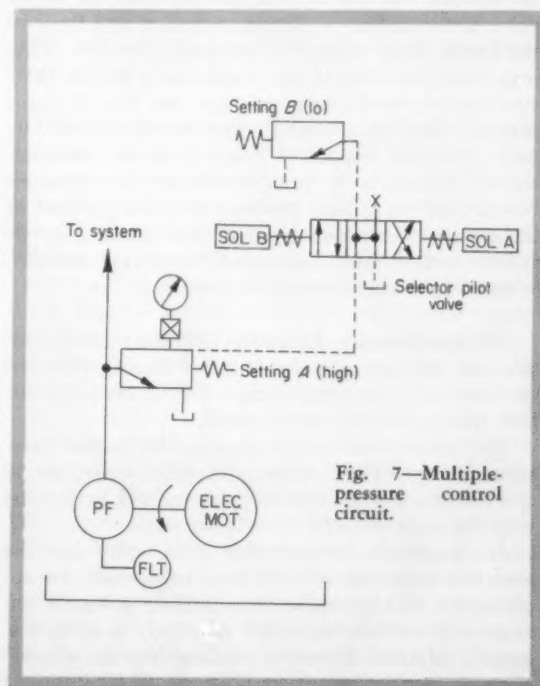


Fig. 7—Multiple-pressure control circuit.



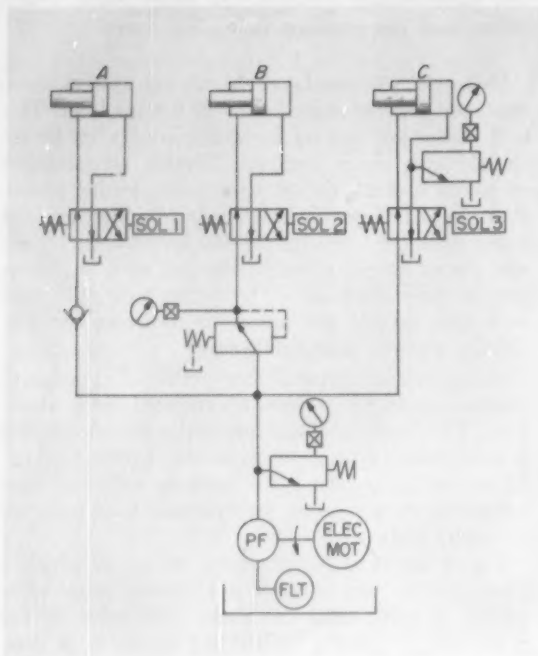


Fig. 8—Reducer/pressure branch-line circuit.

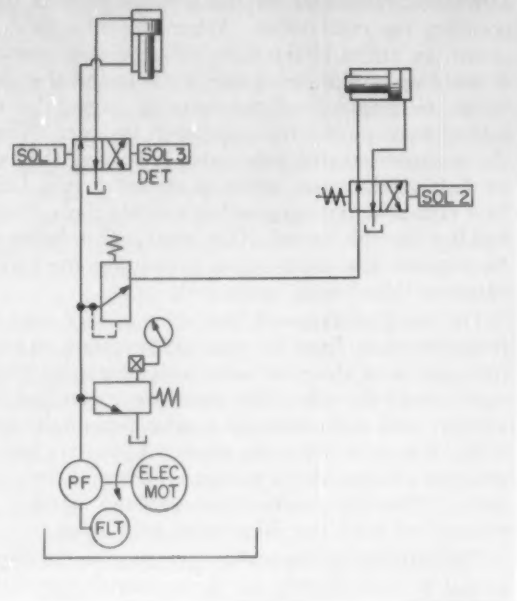


Fig. 9—Pressure sequence valve.

However, this type of accumulator pressure control lacks flexibility.

**Check Valves:** Although normally considered to be directional-control valves, check valves are important in pressure-control systems. In the hi-lo circuit, Fig. 6, the check valve prevents loss of high-pressure oil to the unloaded low-pressure side of the system. In the accumulator circuits, the check valve prevents loss of charged pressure and fluid in the accumulator when the pump is unloaded. One important function of the check valve in the pressure-control circuit is to prevent the loss of high-pressure fluid to a low-pressure portion of the circuit. Another important function in the pressure-control circuit is to protect nominal low-pressure components from high pressure in other portions of the circuit. This arrangement often permits an efficient design, both functionally and economically, which might not otherwise be possible.

**Multiple-Pressure Control:** Different maximum-pressure settings may be required during different portions of a machine cycle. Fig. 7 shows a circuit that meets this requirement.

The main relief valve controls the higher pressure setting. The remote pilot relief valve, set to open at the lower pressure, is connected in parallel with the main valve by the selector valve.

An adjustable, remote-pilot relief valve may be used in conjunction with a main relief valve for applications which require intermediate pressure settings over an infinite range, or which must be frequently adjusted. However, the length of the remote-pilot oil line is limited to 12 to 15 feet because of

the compressibility of the fluids. Greater length of oil line may produce erratic control.

If continuous remote pressure adjustment is required over greater distances than 12 to 15 ft, electric or hydraulic motors can be used to position the pilot control of the main relief valve. The setting must be checked with the pressure gage at the operator station.

If more precise control, or if infinitely adjustable, preset pressure control is required, servoactuators can be used to set the main relief valve. Very precise control can be obtained with a servo pressure-control valve off the main line. The main relief valve is used only to insure a safe maximum pressure level.

### ► Branch-Line Pressure

To operate several hydraulic functions simultaneously under various conditions of operation, specialized pressure-control valves are necessary. These auxiliary pressure-control valves are used primarily on branch circuits. Additionally, the relief valve and the accumulator can be arranged to perform auxiliary functions on branch circuits.

**Pressure-Reducing Valve:** This valve is normally open until the low pressure downstream of the valve increases to the setting on the valve. Then the valve closes to allow only enough flow to maintain system leakage. Fig. 8 illustrates typical applications of pressure-reducing valves. During the retracting stroke, cylinders A and B are subjected to the maximum system pressure, controlled by the main relief valve. Cylinder B is subjected to a reduced pressure controlled by the reducing valve in

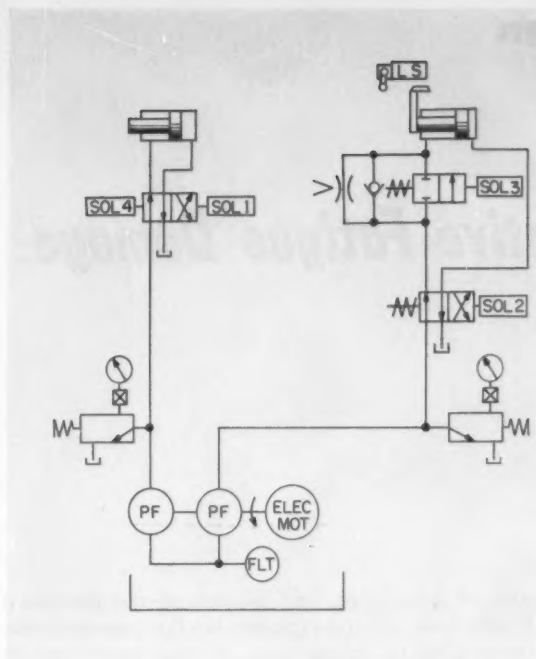


Fig. 10—Double pump.

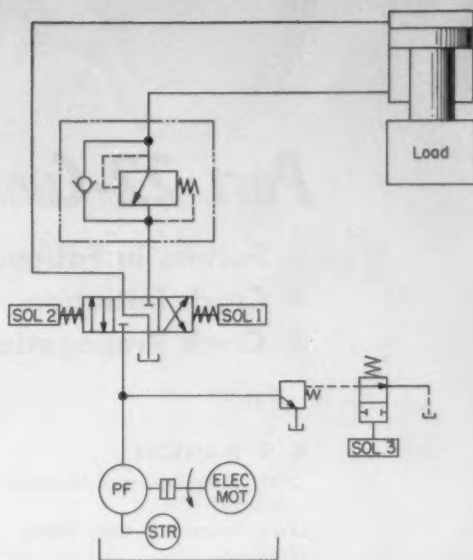


Fig. 11—Counterbalance valve.

its branch supply line. During the extending stroke, cylinder A advances with pressure as controlled by the main relief valve setting of the system. Cylinder B advances with the pressure controlled by the reducing-valve setting. If the external resistance to the movement of cylinder B is low, then the system pressure will be low also. Cylinder C advances at a pressure controlled by the relief valve between the directional valve and the cylinder. While the branch circuit relief valve limits the pressure during the advancing stroke of cylinder C it also limits the maximum pressure available on the entire circuit during this portion of the hydraulic cycle. This pressure lowering effect of a branch-circuit relief valve can be used to limit the input power during portions of the cycle.

Pressure-reducing valves should be vented to the tank to prevent downstream pressure buildups because of leakage past the valve.

If the external force applied to the cylinder is sufficient to cause flow in excess of 0.5 to 0.75 gpm, a separate branch relief valve should be installed between the cylinder and the reducing valve to relieve the pressure buildup. The branch relief valve should be set slightly higher than the reducing valve.

**Pressure-Sequence Valve:** Fig. 9 shows the application of a pressure-sequence valve to maintain a predetermined pressure in one branch circuit while a second branch circuit is operated. A sequence valve is a normally-closed, generally internally-piloted, pressure-control valve, which stays closed until the supply pressure reaches the setting of the valve.

Sequence valves, with built-in check valves for reverse free flow, control several hydraulic cylinders

in sequence with one main four-way directional-control valve. This arrangement provides independence of supply pressure.

A double pump can also be used to supply independent pressure to each branch of a circuit as shown in Fig. 10. To simplify mechanical installation and assembly of the power unit for the system, double pumps include two independent pumping elements in a common housing with a common suction line and independent discharge lines. The relief valves may be built into the double pump assembly, also.

**Counterbalance Valve:** In most hydraulic circuits, resistance should be kept as low as possible. However, in some applications, it may be necessary to introduce resistance valves in various parts of the circuit. This resistance can be supplied by a counterbalance valve, which is a normally-closed two-way valve with an internal pilot supply and an internal drain line. A builtin check valve to permit reverse free flow is usually included. The counterbalance valve can be used to prevent the dropping of a suspended load supported by a hydraulic cylinder, as shown in Fig. 11. If the counterbalance valve were not in this circuit, the load would cause the cylinder to drop faster than the pump flow would normally drive it. Thus, control of the load would be lost. With the counterbalance valve set at a pressure slightly higher than that required to raise the load against the force of gravity, the cylinder will move downward at a speed controlled by pump delivery. The load is raised by free flow of the oil through the check valve built into the counterbalance valve.

## Part 22-Cumulative Fatigue Damage

- Factors in Fatigue
- Crack Initiation
- Crack Propagation

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**C**UMULATIVE damage in fatigue is complicated by introduction of nonrepetitive loading history. Thus, generalized procedures cannot be provided to rigorously indicate the mechanism of the process and at the same time be sufficiently simple to apply for engineering purposes. This article will emphasize the applicability aspect. But, the relations provided are as consistent as possible with the present state of knowledge on fatigue and material behavior under complex loading conditions.

Usable relations for cumulative fatigue damage must be developed for at least two separate cases:

1. When initiation of a macrocrack will terminate the useful life of the machine part because the presence of a crack causes either part fracture or removal of the part from service.
2. When the useful life of the part includes an appreciable period during which the crack continues to propagate.

Different mathematical formulations appear to be most useful for each of these two cases, although many practical problems involve a transition zone between the two extremes. Also, because thermal-stress systems are in part internally balanced systems, the development of a crack alters the internal constraints. Frequently this alteration is beyond the analyst's ability to account for the detailed stress and strain distribution. Thus, conclusions drawn from fatigue tests involving external loading may be only indicative of what can be expected to be valid in thermal-stress systems.

### ► Factors in Fatigue

The process whereby damage accumulates in fatigue is extremely complex. Many important factors, therefore, are omitted because of the incomplete

state of knowledge, and because of the individual behavior of different materials. For example, the importance of temperature on the metallurgy of materials has been discussed and the temperature variable is undoubtedly very significant in damage accumulation.<sup>3</sup> However, much complexity would be involved if this variable were included. Hence, the behavior of materials is discussed as if the temperature remained constant and as if no predominant temperature-dependent metallurgical phenomena occurred. Wherever possible, however, temperature dependency is included.

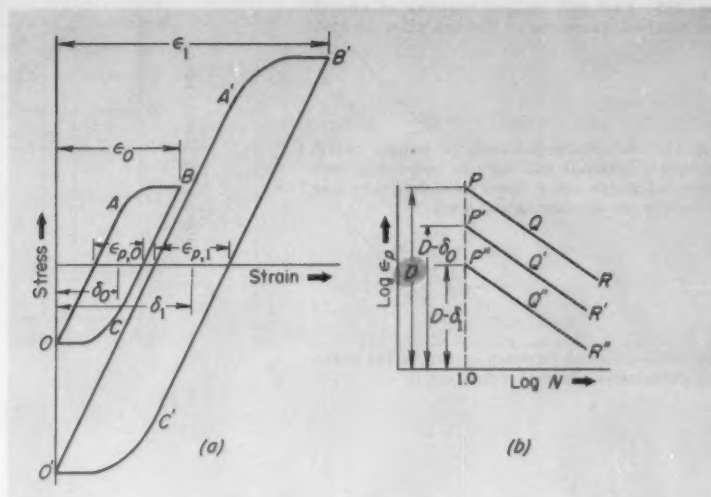
The elementary variables only require that special attention be given to at least three factors when cumulative fatigue is involved.

**Shift in Axis of Mean Strain:** Application of a mean strain prior to initiation of strain cycling alters the constant  $K$  in Equation 11 because of the influence of the prestrain on the effective ductility of the material.<sup>19</sup> The discussion thus far has been limited to initial straining, followed by cycling to failure. Changes in mean strain must, however, be considered even if there is no change in the steady load as indicated in Fig. 133. Assume that a material is being cycled through strain range  $\epsilon_0$ , measured from a reference length taken as the vertical axis. The hysteresis loop is indicated by the solid lines  $OABCO$ , Fig. 133a. Effectively the material is cycled with plastic prestrain  $\delta_0$  and plastic strain range  $\epsilon_{p,0}$  about this prestrain condition. If the strain range is increased to  $\epsilon_1$ , while always returning the material to its original length, then when the asymptotic stress range vs. strain range is achieved, the hysteresis loop becomes  $O'A'B'C'O'$ , having a plastic prestrain  $\delta_1$ . It is, therefore, as if the material was first plastically stretched an amount  $(\delta_1 - \delta_0)$ , and then strain cycled about this condition.

The effect of the changes in mean strain on the life relation,  $\epsilon_p$  vs.  $N$ , are shown in Fig. 133b. If  $PQR$  is the life characteristic of the material in the virgin condition when cycled around a zero mean

<sup>3</sup>References are tabulated at end of article.

Fig. 133—Effect on mean strain and on life due to changes in strain cycling range.



strain,  $P'Q'R'$  becomes the life characteristic when cycled about a plastic prestrain  $\delta_0$ , and  $P''Q''R''$  is the life characteristic when the mean strain is  $\delta_1$ . The effect of changes in prestrain, whether induced by changes in strain cycling range, or by changes in external loading, is to displace the life characteristic vertically by known amounts. This does not include, of course, the effect on the life characteristic of any cycling that actually occurred at  $\epsilon_{p,0}$ .

**Life Depletion by Cyclic Straining:** In addition to the effect of static prestraining, the application of cycles of alternating strain affects the remaining life at another condition of cyclic strain. Magnitude of this effect depends on the various phases involved in the fatigue process. Basically there are at least three major phases preceding fatigue fracture. In the very early phases, the plastic-flow work hardens or softens the material, gradually depleting the capacity of the material for further slip. If the plastic flow is very small, this hardening phase may not be detrimental to life at a subsequent higher strain. Actually it may improve the later life at a higher stress range by increasing the elastic component, and thus reducing the plastic component associated with a given total strain. Hence, "understressing" slightly below the endurance limit can, for some materials, have a "coaxing" or beneficial effect on life at stresses above the endurance limit. At moderate strains, however, exhaustion of slip capacity ultimately results in the development of microcracks which progressively grow with continued cycling. This is the second phase of the fatigue process. The third phase is the growth of the macrocrack, culminating in section fracture.

The coaxing effect is not included here because of the analytical complexity and because most of the practical problems involve strains well above those associated with the endurance limit. Also omitted is the consideration of beneficial cyclic prestraining which produces a hardening without introducing damage of the internal structure. More experimental data are necessary to formulate a hypothesis of material behavior for this range. Hence, discussion

is concentrated on the range where prior history is expected to have damaging effect in subsequent straining. The problem is to account analytically for a known prior history.

Fig. 134 shows a simple approach for analyzing prior strain-cycling history. All strain cycling takes place under a zero mean strain, and the effect of the prestrain is introduced later. The life characteristic of the material prior to any cyclic history is  $PQR$ . At plastic strain  $\epsilon_{p,1}$  the life would be  $N_1$ . But, let the material be cycled at this strain level for only  $n_1$  cycles, where  $n_1 < N_1$ . To estimate the remaining  $\epsilon_p$  vs.  $N$  characteristic  $P'Q'R'$  for the material that has already been subjected to  $n_1$  cycles at a plastic strain of  $\epsilon_{p,1}$ , a hypothesis is used that states that, since the general characteristic of the  $\epsilon_p$  vs.  $N$  relation is a straight line on log-log co-ordinates, the characteristic for the prestrained material will also be such a line. The slope of this line is the same as  $PQR$ , usually  $-1/2$ . Since the slope is known, only one point on the line need be known to determine the line. This point is  $Q'$  at a plastic strain  $\epsilon_{p,1}$  and the life is

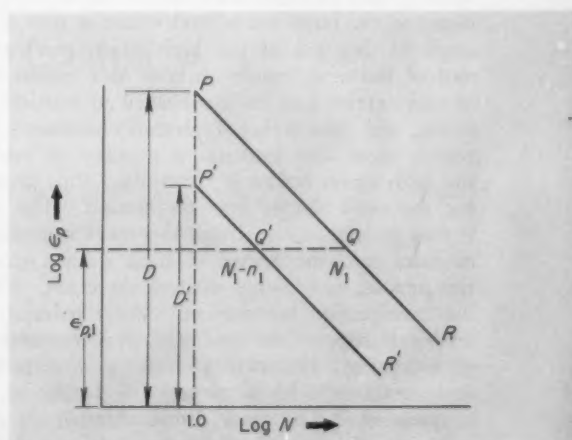


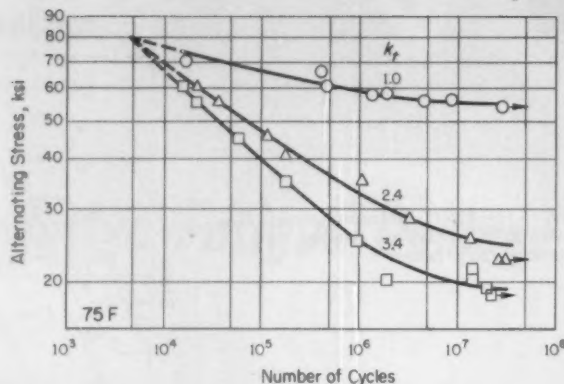
Fig. 134—Effect of prior cycling on remaining life.



Fig. 135—Push-pull fatigue behavior of smooth and notched specimens of Timken alloy 16-25-6.

Fig. 136—Schematic behavior of fatigue curves for virgin material and for one which has been precycled at one stress level followed by cycling to failure at another stress level.

Fig. 137—Relation between  $\epsilon_p$  and  $N$  for deriving cumulative damage relationship.



135

( $N_1 - n_1$ ). Thus,  $P'Q'R'$  can be constructed graphically or treated analytically. The effect of a prior strain history is seen to shift the  $\epsilon_p$  vs.  $N$  line to the left by a known amount. Fig. 134 indicates that the effect of prior straining reduces the ductility from  $D$  to  $D'$ , the point of intersection of  $P'Q'R'$  with the line  $N = 1$ .

**Influence of Crack Propagation:** While the development of a macrocrack may occasionally trigger catastrophic propagation, other cases involve a fairly slow propagation of the crack. The greatest part of the fatigue history may, in fact, be consumed by the crack-propagation stage and only a small portion in the crack-initiation phase.

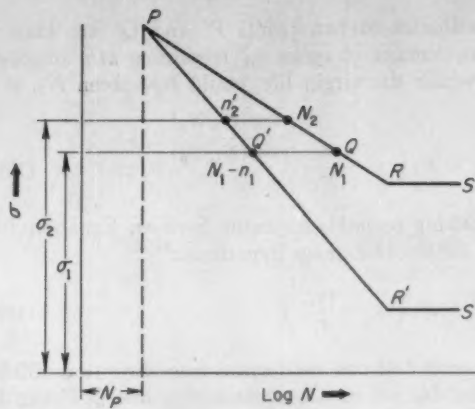
One such case that emphasizes the crack propagation phase is the push-pull fatigue test of a severely notched specimen. Here the strain is not uniform across the test section, an extremely high strain concentration factor exists at the root of the notch. In the plastic range the strain concentration factor is even higher than the elastically computed value. Thus a few early cycles at the very high reversed plastic strain are sufficient to cause a crack at the root of the notch. The development of the crack produces an even greater strain concentration, but not in the same volume of metal that had previously been subjected to the large strain, and which is now already cracked. Because of the high strain gradient, the root of the new "notch" is now in a region which in early cycles had been subjected to relatively low strain, and thus is not appreciably damaged. The region must first undergo a number of cycles at the high strain before it "fractures," thus propagating the crack deeper into the section. The action is thus progressive, the deepening crack bringing new material into the region of high strain, which in turn cracks, and further deepens the crack. Finally, the cross-section becomes sufficiently reduced to be unable to support the load, and thus fractures completely. Fig. 135 shows some push-pull fatigue test results for Timken 16-25-6 alloy at room temperature.<sup>23</sup> The curve drawn through the circles represents the smooth-bar fatigue characteristic for this material used as a reference. The other two

curves are for specimens which contained notches having nominal elastic stress-concentration factors of 2.4 and 3.4, respectively. Data in the range of a very low number of cycles range are not available. But, the data in the range of a high number of cycles indicate that the curves get closer to each other in the low cycle range, and could reasonably be assumed to converge to a single point. Thus, the effect of a stress (or strain) concentration factor is relatively minor in the low cycle range, but, assumes greater and greater importance as the stress range is decreased.

Introducing a crack, or any other form of stress-concentration factor rotates the  $\sigma$  vs.  $N$  curve about some hypothetical point in the low cycle, high-stress range. This observation is used to determine a first approximation of the remaining  $\sigma$  vs.  $N$  curve of a material that has undergone a known prior stress or strain history. Thus, it forms the basis of an approach for analysis of cumulative damage in the low cycle high-stress range.

In Fig. 136,  $PQR$  is the  $\sigma$  vs.  $N$  characteristic in a notched material. At a cyclic stress of  $\sigma_1$ , the number of cycles to failure would be  $N_1$ . If only  $n_1$  cycles are applied, it can be assumed that the notch propagates by crack formation, producing a more severe effective stress concentration. To determine the  $\sigma$  vs.  $N$  curve for the material that has already undergone  $n_1$  cycles at  $\sigma_1$ , the point  $Q'$  on this curve can first be located, since at a stress of  $\sigma_1$  the remaining life is known to be  $(N_1 - n_1)$  cycles. If point  $P$  is known as a material characteristic, line  $P'Q'R'$  can be drawn. This procedure is useful in developing a relation for cumulative damage under conditions in which crack propagation is an important component.

Another characteristic of fatigue behavior which becomes important when crack propagation is a predominant factor is illustrated in Fig. 136. This relates to the reduction in endurance limit of a material that has seen prior service. Thus, if  $RS$  represents the initial endurance limit, the endurance limit of the material that has already been subjected to  $n_1$  cycles at  $\sigma_1$  is  $R'S'$ . The higher stress concentration, together with the lower load-resisting area re-



136

sulting from the crack imposed by prior service, causes the material to assume finite life in a range where the life was previously indefinitely large. This factor must be accounted for in a cumulative-damage hypothesis where crack propagation is important.

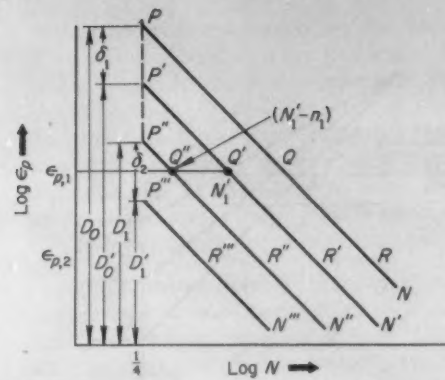
### ► Crack Initiation

The simplest case of cumulative damage leading to the point of crack initiation is the push-pull fatigue test of a smooth specimen. Here the entire volume of the cross section is under approximately uniform strain. When the prior strain history has been sufficiently severe to cause a crack at the surface, an intensified strain is induced in the sub-surface due to the strain concentration associated with the crack. Since this material has already been exposed to a prior strain history which is approximately the same as that of the surface, the crack propagation is rapid through the cross section. Hence, in developing a formulation of cumulative damage for a machine part subjected to such an application, only the first two *Factors in Fatigue* need be considered and combined.

**Combining Prestrain and Prior Cycling:** Application of the principles for combining the effect of prestrain and prior cycling is indicated in Fig. 137. The effect of applying a unidirectional tensile plastic strain  $\delta_1$  to a material which has an initial ductility  $D_0$  is considered first. If  $PQR$  is the initial  $\epsilon_p$  vs.  $N$  characteristic of the material prior to plastic straining, the  $\epsilon_p$  vs.  $N$  characteristic is line  $P'Q'R'$  vertically displaced from  $PQR$  by a distance  $\delta_1$ . The equation of  $P'Q'R'$  becomes

$$N = \frac{(D_0 - \delta_1)^2}{\epsilon_p^2} \quad (184)$$

If unidirectional plastic strain  $\delta_1$  is followed by  $n_1$  cycles of plastic strain  $\epsilon_{p,1}$ , the questions raised are: What is the remaining ductility in the material and what is the equation for the  $\epsilon_p$  vs.  $N$  curve for the material after it has undergone the above operation? The construction is shown in Fig. 137. Since the



137

remaining life at  $\epsilon_{p,1}$  after the application of  $\delta_1$  is  $N_1'$  at point  $Q'$ , and since  $n_1$  cycles are used up, then the remaining life at a reverse plastic strain of  $\epsilon_{p,1}$  is obviously  $(N_1' - n_1)$  at point  $Q''$ . The  $\epsilon_p$  vs.  $N$  curve must, therefore, be a line of slope  $-1/2$  through  $Q''$ . The equation of line  $P''Q''R''$  can be determined from Equation 184:

$$N'' = \frac{(D_0 - \delta_1)^2 - n_1 \epsilon_{p,1}^2}{\epsilon_p^2} \quad (185)$$

Therefore, the remaining ductility is

$$D_1 = [(D_0 - \delta_1)^2 - n_1 \epsilon_{p,1}^2]^{1/2} \quad (186)$$

Unidirectional strain  $\delta_2$  is added by locating point  $P'''$  at distance  $\delta_2$  below  $P''$  and writing the equation of a line through  $P'''$  with slope  $-1/2$ . Hence,

$$D_1' = [(D_0 - \delta_1)^2 - n_1 \epsilon_{p,1}^2]^{1/2} - \delta_2 \quad (187)$$

and

$$N''' = \frac{\{[(D_0 - \delta_1)^2 - n_1 \epsilon_{p,1}^2]^{1/2} - \delta_2\}^2}{\epsilon_p^2} \quad (188)$$

The process can be compounded for the general case in which any number of unidirectional strains are successively followed by reverse plastic strains by sequentially constructing parallel lines in Fig. 137 and writing the equations of these lines. The general equation for the remaining ductility is

$$D_q = \left\{ \dots \left[ \left\{ \left[ (D_0 - \delta_1)^2 - n_1 \epsilon_{p,1}^2 \right]^{1/2} - \delta_2 \right\}^2 - n_2 \epsilon_{p,2}^2 \right]^{1/2} - \delta_3 \right\}^2 - n_3 \epsilon_{p,3}^2 \dots - n_q \epsilon_{p,q}^2 \right\}^{1/2} \quad (189)$$

The general equation for the life becomes

$$N = \frac{D_q^2}{\epsilon_p^2} \quad (190)$$

Equation 189 resembles a familiar equation commonly encountered in fatigue theory: The sum of the cycle ratios for a sequence of loading is equal to unity. Furthermore, the order of applications of loadings does not alter the final result. On the other hand, when unidirectional plastic straining is in-

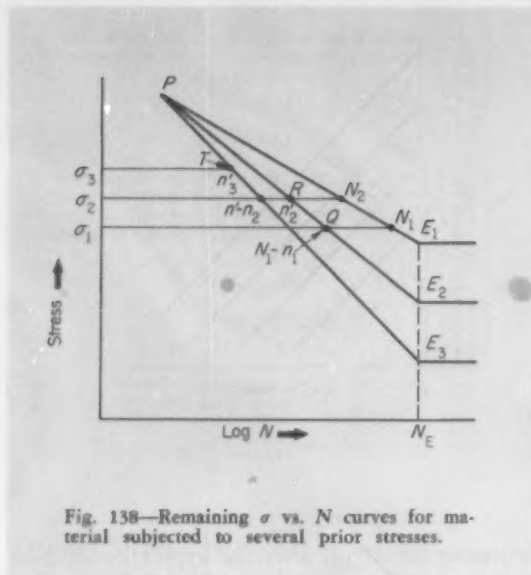


Fig. 138—Remaining  $\sigma$  vs.  $N$  curves for material subjected to several prior stresses.

cluded, the order of sequential loading does affect the final result.

### ► Crack Propagation

Whereas cases involving approximately uniform-stress distribution are best analyzed on the basis of the number of cycles to initiate the crack, those involving nonuniform stress or strain distribution must give weight to crack propagation as well. Initiation of a crack in a region of high strain does not necessarily lead to rapid propagation because the material that is progressively drawn into a condition of high strain by the advancing crack had not previously been seriously damaged at the considerably lower strains to which it had been subjected. Thus, each element of material requires a number of cycles at the high strain before it fails and contributes an increment of crack propagation.

This problem is best approached by considering the observed behavior of materials in tests wherein the strain distribution is not uniform. Typical cases of this type are rotating bending tests of smooth specimens and push-pull tests of notched specimens. The direct applicability of the results of such an analysis to cases involving thermal stress requires considerable experimental verification. A propagating crack in a mechanically loaded system tends to intensify the localized load at the crack front because of reduction in load carrying area. Such propagation in thermal-stress problems tends to be self-relieving because the loading is produced by internal constraints which diminish as the crack progresses.

**Life Relation:** The simplified basis for the cumulative-damage relation has been discussed in connection with Fig. 136.<sup>23</sup> If  $N_p$  is the value of the abscissa at apex  $P$ , then the equation for  $\sigma$  vs.  $N$  line  $PQR'$  for the material that has already been subjected to  $n_1$  cycles at  $\sigma_1$  can be written, since the

co-ordinates of two points  $P'$  and  $Q'$  are known. Thus, number of cycles  $n_2'$  remaining at a stress  $\sigma_2$ , for which the virgin life would have been  $N_2$ , is

$$n_2' = N_2 \left( 1 - \frac{n_1}{N_1} \right)^{\frac{\log(N_2/N_p)}{\log(N_1/N_p)}} \quad (191)$$

A striking resemblance exists between Equation 191 and the linear-damage hypothesis:<sup>24,25</sup>

$$n_2' = N_2 \left( 1 - \frac{n_1}{N_1} \right) \quad (192)$$

Equation 192 can be derived from Equation 190 by taking  $N_p = \infty$ . Or equivalently, line  $Q'P'$  can be drawn through known point  $Q'$  parallel to the basic  $\sigma$  vs.  $N$  line,  $PQ$ , instead of converging to intersection point  $P$ . For  $\sigma$  vs.  $N$  relations that are curved instead of linear, the linear-damage relation implies a displacement of the curve parallel to the  $N$  axis.

For a history that consists of  $n_1$  cycles at  $\sigma_1$  followed by  $n_2$  cycles at  $\sigma_2$ , the procedure for determining the remaining  $\sigma$  vs.  $N$  curve is indicated in Fig. 138. Point  $Q$  is first located at stress  $\sigma_1$  and number of cycles  $(N_1 - n_1)$ , and line  $PQ$  is drawn as the remaining  $\sigma$  vs.  $N$  line after the first prestress. Point  $R$  is now located at stress  $\sigma_2$ , and the number of remaining cycles  $n_2'$  at this stress is determined. Since  $n_2$  cycles are subsequently used up, the remaining number of cycles at this stress is  $(n_2' - n_2)$ . Thus at this stress, the point  $S$  on remaining  $\sigma$  vs.  $N$  line can be located. If it is assumed that the final  $\sigma$  vs.  $N$  line also passes through point  $P$ , line  $PS$  can be drawn. If it is desired to develop an analytical relation, it is best to express the final form in terms of known values  $N_1$  and  $N_2$  which constitute cyclic lives at  $\sigma_1$  and  $\sigma_2$  in the original material. The final form becomes

$$\frac{n_3'}{N_3} = \left[ \left( 1 - \frac{n_1}{N_1} \right)^{\frac{\log(N_2/N_p)}{\log(N_1/N_p)}} - \frac{n_2}{N_2} \right]^{\frac{\log(N_3/N_p)}{\log(N_2/N_p)}} \quad (193)$$

Again the similarity to the linear-damage rule is apparent. Instead of simply subtracting cycle ratios from unity as required by the linear-damage rule, the effect is compounded by raising to a known exponent the simple expressions associated with each portion of the prior history before subtracting the effect of an additional cycle ratio.

The history dependence of material behavior according to this approach is clear. The linear-damage rule does not distinguish between a history in which  $n_1$  cycles at  $\sigma_1$  precedes or follows  $n_2$  cycles at  $\sigma_2$ . But, the relation shown by Equation 193 does depend on the order in which the history is applied.

The same procedure can be compounded to account for an arbitrary history consisting of  $n_1$  cycles at  $\sigma_1$ ,  $n_2$  cycles at  $\sigma_2$ , etc. Again, it is best to express the final result in terms of the number of cycles to failure at each of the applicable stress levels on the original  $\sigma$  vs.  $N$  curve of the material:

$$\frac{n_{i+1}}{N_{i+1}} = \left[ \dots \left\{ \left[ \left( 1 - \frac{n_1}{N_1} \right) \frac{\log(N_2/N_p)}{\log(N_1/N_p)} - \frac{n_2}{N_2} \right] \frac{\log(N_3/N_p)}{\log(N_2/N_p)} - \frac{n_3}{N_3} \right\} \frac{\log(N_4/N_p)}{\log(N_3/N_p)} \dots - \frac{n_i}{N_i} \right] \frac{\log(N_{i+1}/N_p)}{\log(N_i/N_p)} \quad (194)$$

where  $n_{i+1}$  is the remaining life at any stress level at which the life on the original  $\sigma$  vs.  $N$  curve would have been  $N_{i+1}$ .

Although complicated in appearance, the procedure for applying this formula is very simple. It involves raising to a known exponent the cumulative damage associated with the prior history before subtracting the cycle ratio associated with any portion of the history. Again the order dependence of history is apparent, and the graphical procedure could replace the analytical if desired.

**Effect on Endurance Limit:** One of the important limitations of the linear-damage rule is that it does not make any allowance for cycles applied at stress levels below the endurance limit. When crack propagation is involved, however, small cracks generated by the higher stress levels can result in sufficiently large stress concentrations so that low nominal stresses are sufficient to cause propagation.

The effect of prior loading on the endurance limit is indicated in Fig. 138. Instead of stopping the "remaining"  $\sigma$  vs.  $N$  curves at the initial endurance limit, they are extended until they intersect the vertical line through  $N_p$ , the life at the knee of the initial  $\sigma$  vs.  $N$  curve. While limited experiments have indicated that "knees"  $E_2$  and  $E_3$  of the remaining  $\sigma$  vs.  $N$  curves tend to shift to the left the lower the  $\sigma$  vs.  $n$  line, this approximation is simple yet conservative.

An expression can be derived for the remaining endurance after a material has undergone a history of  $n_i$  cycles at conditions where the lives based on the initial  $\sigma$  vs.  $N$  curves would have been  $N_i$ :

$$\sigma_{E,n} = \sigma_P - \frac{\sigma_P - \sigma_{E,0}}{A} \quad (195)$$

where

$$A = 1 + \log \left[ \dots \left\{ \left[ \left( 1 - \frac{n_1}{N_1} \right) \frac{\log(N_2/N_p)}{\log(N_1/N_p)} - \frac{n_2}{N_2} \right] \frac{\log(N_3/N_p)}{\log(N_2/N_p)} - \frac{n_3}{N_3} \right\} \frac{\log(N_4/N_p)}{\log(N_3/N_p)} \dots - \frac{n_{i-1}}{N_{i-1}} \right] \frac{\log(N_i/N_p)}{\log(N_{i-1}/N_p)} - \frac{1}{\frac{n_i}{N_i} \left[ \log(N_i/N_p) \right]}$$

To find the effect of stresses below the initial limit, it is always necessary to compute, by Equation

195 or its graphical equivalent, the new endurance limit produced by the history which precedes the stress under consideration. If the endurance limit is above the stress to be applied, the effect of this stress may be neglected. If the new endurance limit is lower, however, it is to be included as a regular term in Equation 195. The value of  $N_i$  must then be taken as the life on the original  $\sigma$  vs.  $N$  curve extrapolated to the lower stress under consideration.

**Significance of Point P:** For some materials and fatigue-loading conditions, point  $P$  is a real intersection of the straight  $\sigma$  vs.  $N$  lines. Thus, it is possible for the curve of a notched material to lie higher than that of a smooth material at numbers of cycles less than  $N_p$ . However,  $P$  usually must be regarded as an "apparent" point of intersection of the straight lines that approximates the  $\sigma$  vs.  $N$  curves in the range of available data. No particular physical significance is suggested for the co-ordinates of this point. Not only do the co-ordinates depend on the material, but it is expected that they will depend on the type of test or loading conditions involved. The more uniform the stress distribution, the more parallel the  $\sigma$  vs.  $N$  curves and the more remote the co-ordinates of their intersection. Considerable experimental evidence is as yet required to determine equation validity, and the dependence of the co-ordinates of point  $P$  on material properties and loading conditions.

**Effect of Mean Stress:** The derivation of Equation 194 is based on the assumption that the nominal stresses are completely reversed. When the alternating stress is superimposed on a mean stress, a further approximation is required. One possibility is to apply the same formula except that the number of cycles to failure,  $N$ , at each of the conditions imposed can be chosen to account for the effect of the mean stress. The method for determining the life when mean stress is present has been discussed.<sup>21</sup>

**Effect of Curvature in  $\sigma$  vs.  $N$  Relation:** While the derivation of Equation 194 is based on the assumption of linearity between  $\sigma$  and  $\log N$ , the final term does not contain  $\sigma$ . Since any relation between  $\sigma$  and  $N$  can be made linear by the proper choice of scale, the relation will be valid for all shapes of  $\sigma$  vs.  $N$  curves. The only reservation is that  $N_p$  must be associated with the point of intersection of the original  $\sigma$  vs.  $N$  line and "remaining"  $\sigma$  vs.  $N$  lines for damaged materials when plotted to the same stress scale. The "apparent" points of intersection for two curves which are approximated by straight lines will depend on the choice of type of scale. Thus, the best value of  $N_p$  will be associated with that type of plot in which the  $\sigma$  vs.  $N$  curve is most linear. The determination of  $N_p$  must be made by subjecting a series of specimens to a known number of cycles at a stress for which the number of cycles to failure on the original  $\sigma$  vs.  $N$  curve is known. The "remaining"  $\sigma$  vs.  $N$  curve for the precycled material is then determined, plotted on the same co-ordinates as the original  $\sigma$  vs.  $N$  curve, and the straight lines best representing these curves extrapolated to a common



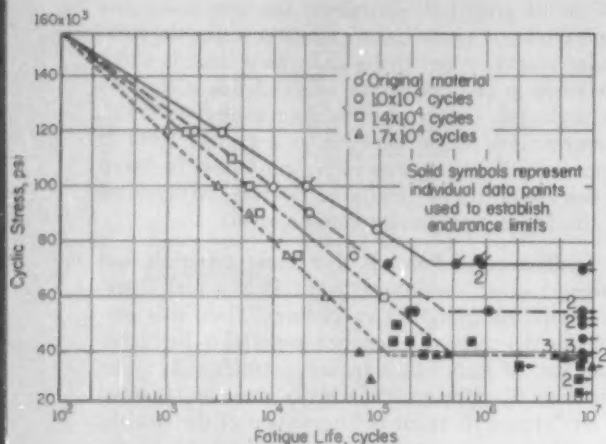


Fig. 139—Test results on cumulative damage of 4130 steel. All cycles at 100,000 psi.

point of intersection. Another possibility is to test notched and smooth materials, using the value of  $N_p$  at the point of intersection of their  $\sigma$  vs  $N$  curves. But, this method has not yet been tried.

**Verification:** Only the barest type of verification has been provided for the cumulative-damage theory described here. Steel has been tested under a limited number of conditions to determine if the remaining  $\sigma$  vs.  $N$  lives on precycled specimens tend to converge to a single point.<sup>25</sup> Fig. 139 shows the results of these tests. Each curve represents the "remaining"  $\sigma$  vs.  $N$  curve for a different number of cycles at this prestress. There is a distinct tendency toward convergence to a common point, although it is also possible that each line is slightly displaced to the left before it is rotated, thus moving the point of intersection along the original  $\sigma$  vs.  $N$  line. The parallel displacement plus rotation may indicate that a more valid theory is possible by combining the effects of the second two *Factors in Fatigue*.

The figure also shows that the endurance limit of precycled materials does decrease and can be approximately determined by the method described.

## ► Thermal-Stress Applications

While the objective of the derivations discussed thus far is the ultimate application to thermal-stress problems, the basis for the derivations has been the behavior of materials in mechanically loaded systems. Little direct evidence, therefore, as yet exists as to the validity of these approximate engineering relations to the problem of direct interest. Their merit is that they can be directly applied, they give definite answers, and until more accurate approaches are available, they can be used if their potential limitations are recognized.

If the beginning of a crack constitutes the point to be regarded as failure, it would appear that Equa-

tions 189 and 190 can be directly applied. Of course, the determination of the individual strain values associated with each portion of the thermal and/or mechanical history constitutes a considerable analytical problem. But, the methods described in this series can be used for reasonable answers. If the static prestrains involved in the problem are small, the relation becomes equivalent to the linear-damage rule.

If crack propagation is to be permitted, and this is the usual case in thermal-stress problems, considerable additional complications appear because of the differences between thermally and mechanically loaded systems. In a mechanically loaded system, the emergence of a crack not only produces a stress concentration, but it reduces areas, moments of inertia, etc., for carrying the external load. As the crack progresses, this effect is accelerated, and the tendency for the crack to propagate increases.

In thermal-stress systems without external load, the emergence of a crack *relieves* to some extent the internal constraint, thereby reducing the thermal loading. The stress concentration is still present, but the effect is not as severe as if the load were external. On the other hand, omission of the temperature effect on the properties would appear at least to offset the conservative aspects of constant relief. Thus, use of Equations 194 and 195 would probably not be too conservative a compromise to balance the two effects, especially if part of the loading is mechanically applied.

## REFERENCES

This article is the twenty-second in a series by S. S. Manson on thermal stresses in design. Earlier parts appeared in the following issues of *MACHINE DESIGN*:

- |                  |                    |                   |
|------------------|--------------------|-------------------|
| 1. June 12, 1958 | 8. Feb. 19, 1959   | 15. Nov. 12, 1959 |
| 2. June 26, 1958 | 9. March 5, 1959   | 16. Nov. 26, 1959 |
| 3. Aug. 7, 1958  | 10. March 19, 1959 | 17. June 9, 1960  |
| 4. Aug. 21, 1958 | 11. July 9, 1959   | 18. June 23, 1960 |
| 5. Sept. 4, 1958 | 12. July 23, 1959  | 19. July 7, 1960  |
| 6. Jan. 22, 1959 | 13. Aug. 6, 1959   | 20. July 21, 1960 |
| 7. Feb. 5, 1959  | 14. Oct. 29, 1959  | 21. Aug. 4, 1960  |

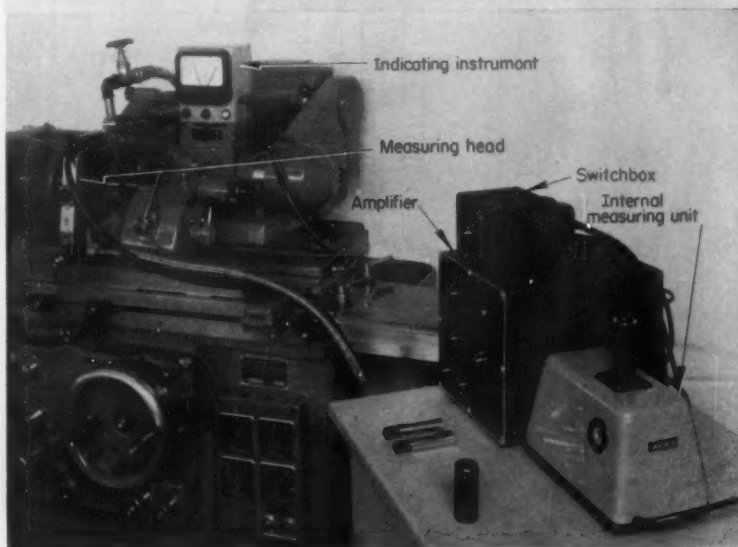
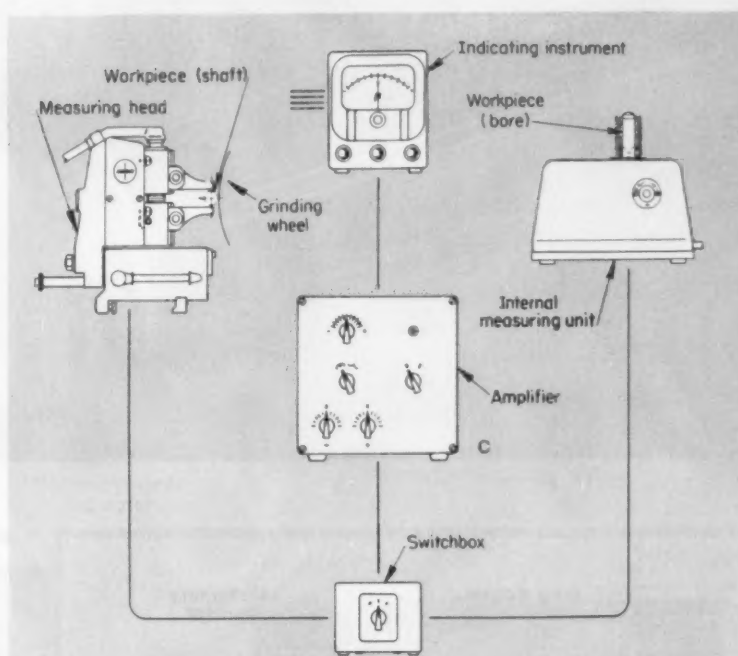
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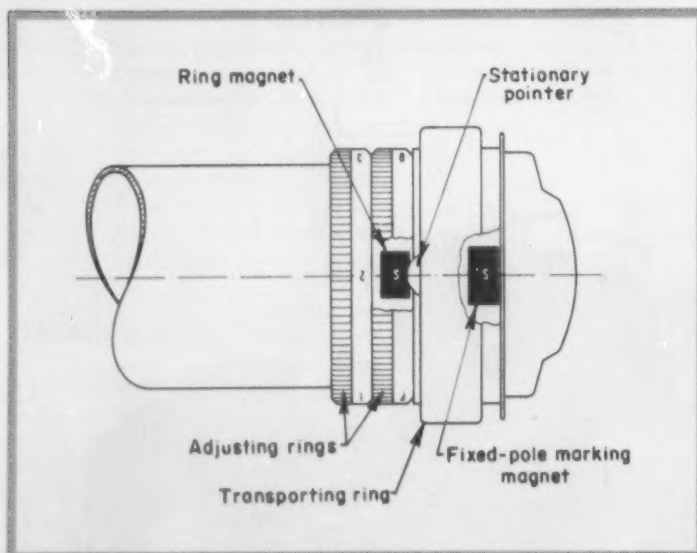
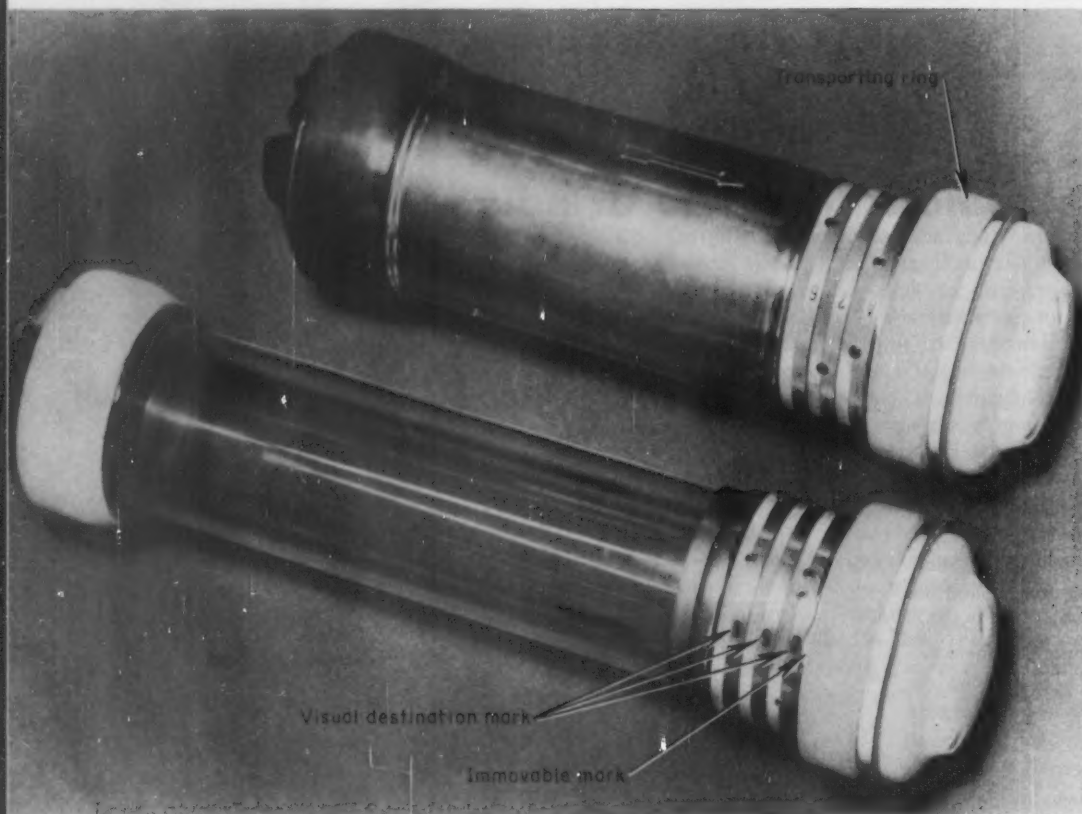
22. F. H. Vitovec and B. J. Lazan—"Fatigue, Creep and Rupture Properties of Heat Resistant Materials," WADC TR 56-181, August, 1956.
23. S. S. Manson, A. J. Nachtigall, and J. C. Freche—"A Proposed New Relation for Cumulative Damage in Rotating Bending Cyclic Stresses," to be published.
24. A. Palmgren—"Die Lebensdauer von Kugellagern," *ZVDI*, Vol. 68, pp. 339-341, 1924.
25. M. A. Miner—"Cumulative Damage in Fatigue," *Journal of Applied Mechanics*, Vol. 12, pp. A159-A164, 1945.
26. J. A. Bennett—"A Study of the Damaging Effects of Fatigue Stressing on X4130 Steel," *Proceedings ASTM*, Vol. 46, pp. 693-711, 1946.

This article concludes the current series in *MACHINE DESIGN* on thermal stresses. Material contained in this 22-part series will be included in a forthcoming book by S. S. Manson to be published by McGraw-Hill Book Co. Inc., New York.

## Electronic Calipers Control Automatic Selective Grinding Machine

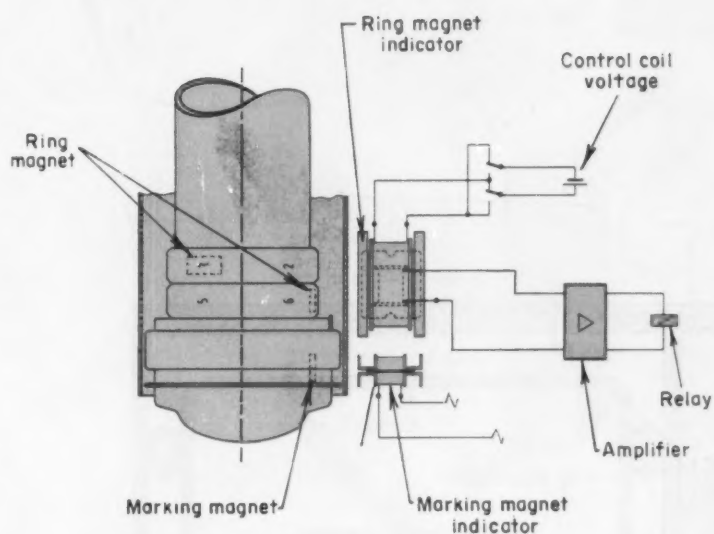
**ELECTRONIC CALIPERS DETERMINE** difference in diameters rather than exact sizes. Shaft can be ground to required fit with hub rather than a specific, tightly tolerated dimension. Finished hub or bushing is placed over the internal calipers as a reference. Shaft is ground on a centerless grinder with external calipers giving it a running check. When the diameter reaches a size that includes any required clearance, the machine is automatically shut off and arbor retracted. Novomatic SA, Neuchatel, Switzerland, designed the matching grinder.



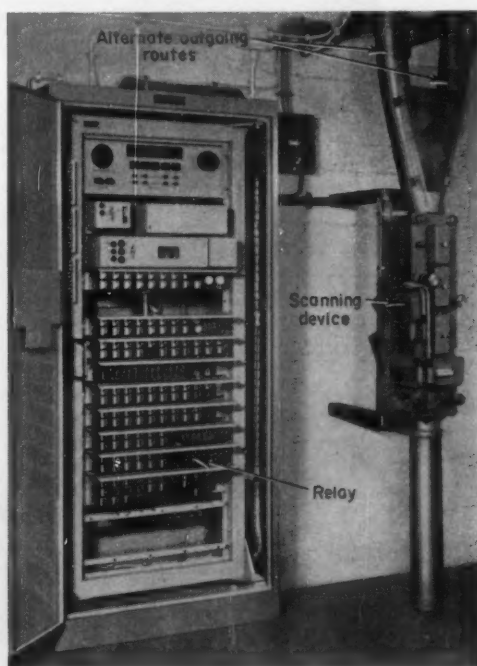
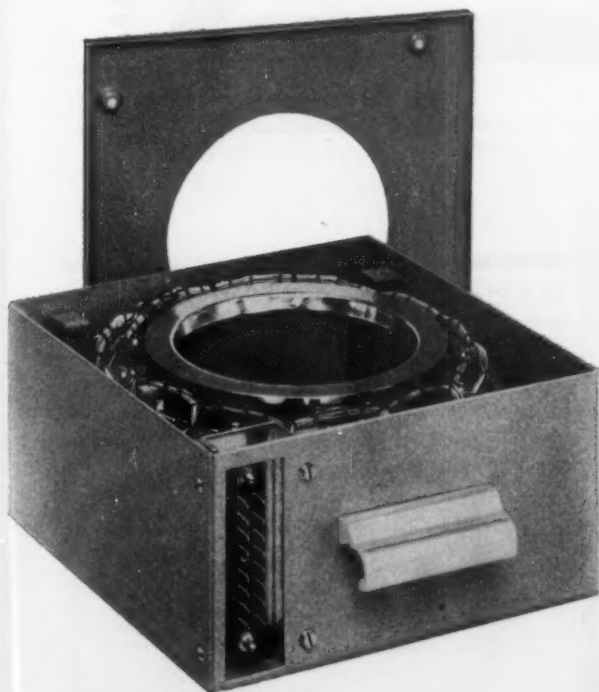


**MAGNETIZED RING REPRESENTS** a letter or number by the position of its magnetic poles in relation to a fixed pole. Ring surface is marked with its repertoire of symbols. Symbol is "written in" by turning the ring until its printed mark is opposite a stationary pointer. Pneumatic-tube carrier's destination can be codified by the use of two or three of these rings on the carrier body. It's less bulky than previous methods and leaves the carrier more room for goods or messages.

## Rotatable Rings Register Pneumatic Carrier Destination

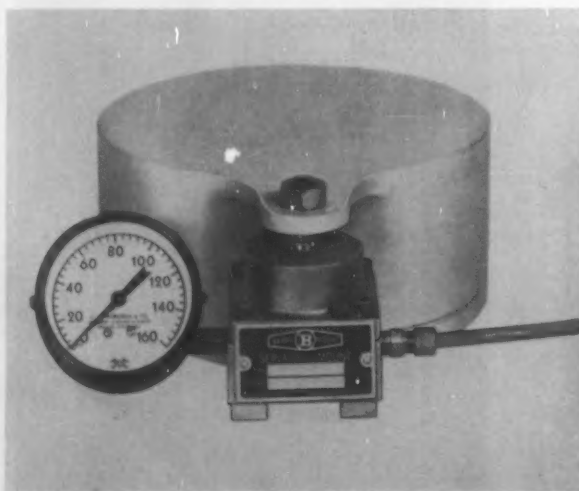
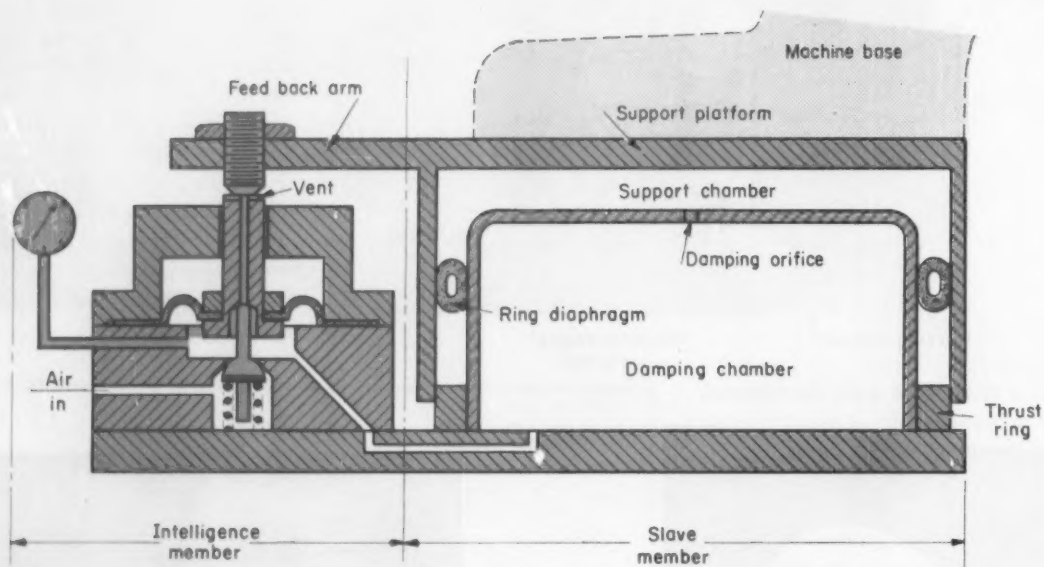
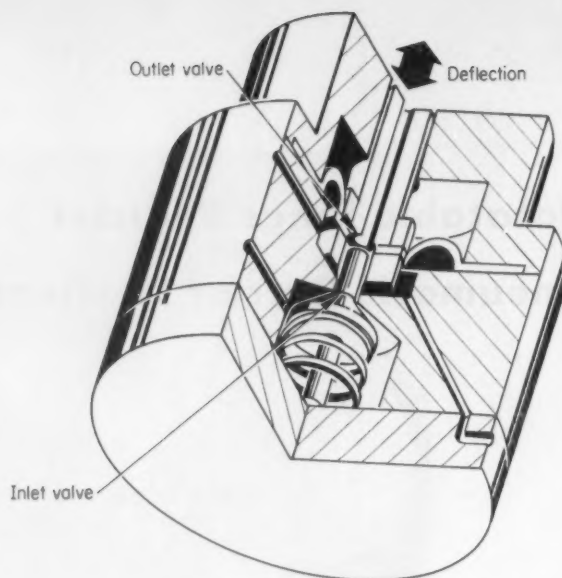


**CODE IS INTERPRETED** by automatic readout unit at the dispersion station of a multiple-route pneumatic tube system. A circle of indicator coils is provided for each code ring on the carrier. Indicator coils change their resistance to alternating readout current passing through them when in the influence of a ring's magnetic field. Phase sense of the change distinguishes north from south pole. Marking magnet indicator orients the code pattern. Relays open and close gates to direct the carrier in the proper course. Standard Elektrik Lorenz AG, Stuttgart, Germany, developed the magnetic coding system.





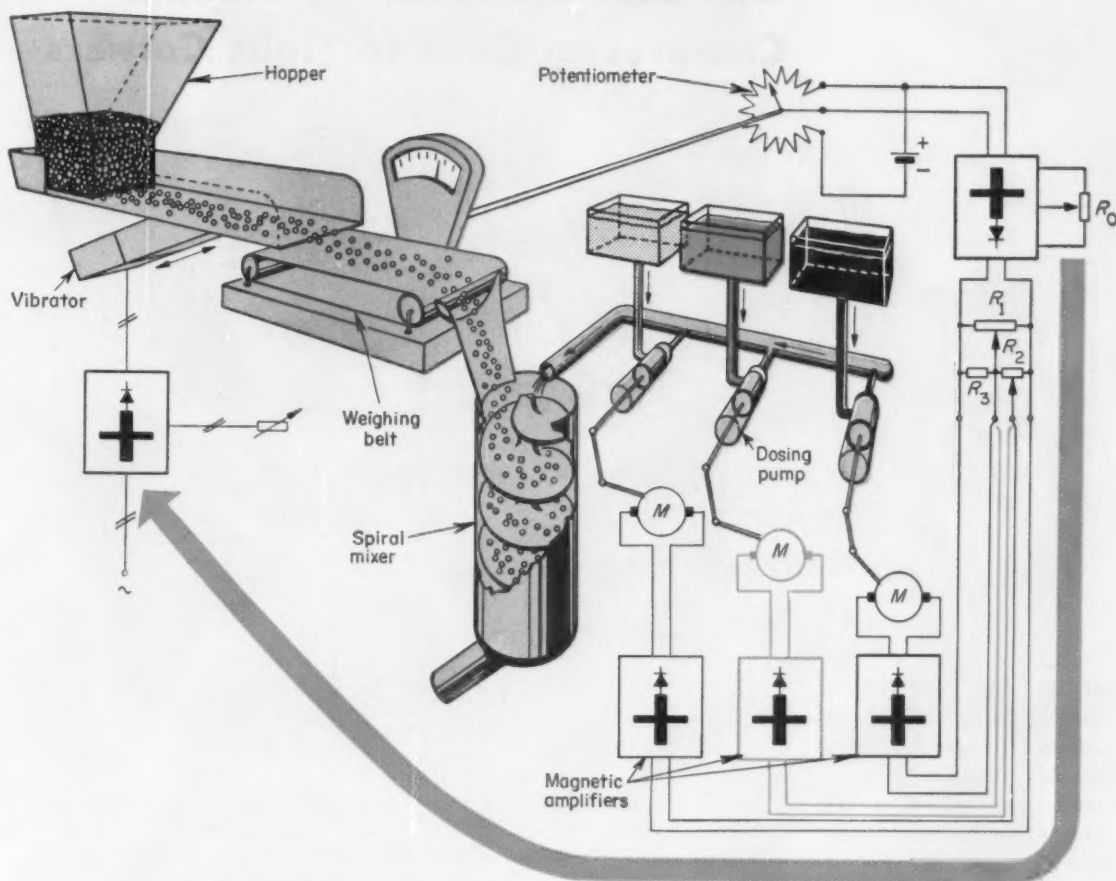
## Air Valve Senses Load Changes In Pneumatic Leveler



**SLIGHT SHIFT** in position of a supported load is sensed by a new leveling device, and a pneumatic valve is opened to bring the load back to level. Downward deflection of the mount opens the inlet valve, allowing pressurized air to enter the support chamber until it is restored to its original position. Upward deflection of the mount lifts the valve seat from the outlet valve, causing the support chamber to lose air until it has returned to level position. Serva-level mount is produced by Barry Controls Inc., Watertown, Mass.

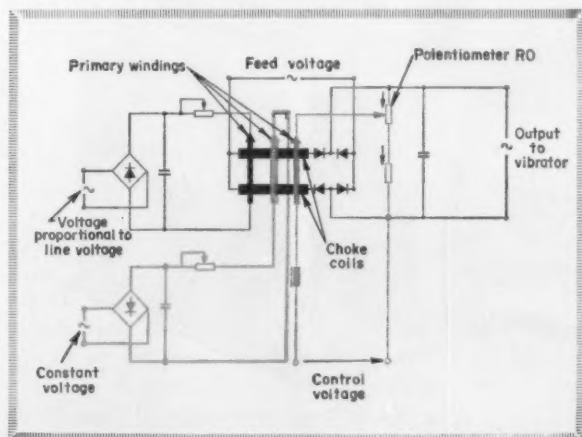
## Double Servo System

- Controls Mixing Ratio
- Maintains Rate of Flow



**OUTPUT OF CONTINUOUS WEIGHER** feeds control signals to dosing pumps and vibrator. Resistances ( $R_1$ ,  $R_2$ , and  $R_3$ ) proportion output correctly between

dosing pumps to provide fluid mix in the right ratio regardless of the level of the input voltage. Resistance  $R_0$  feeds back signal to vibratory feed.



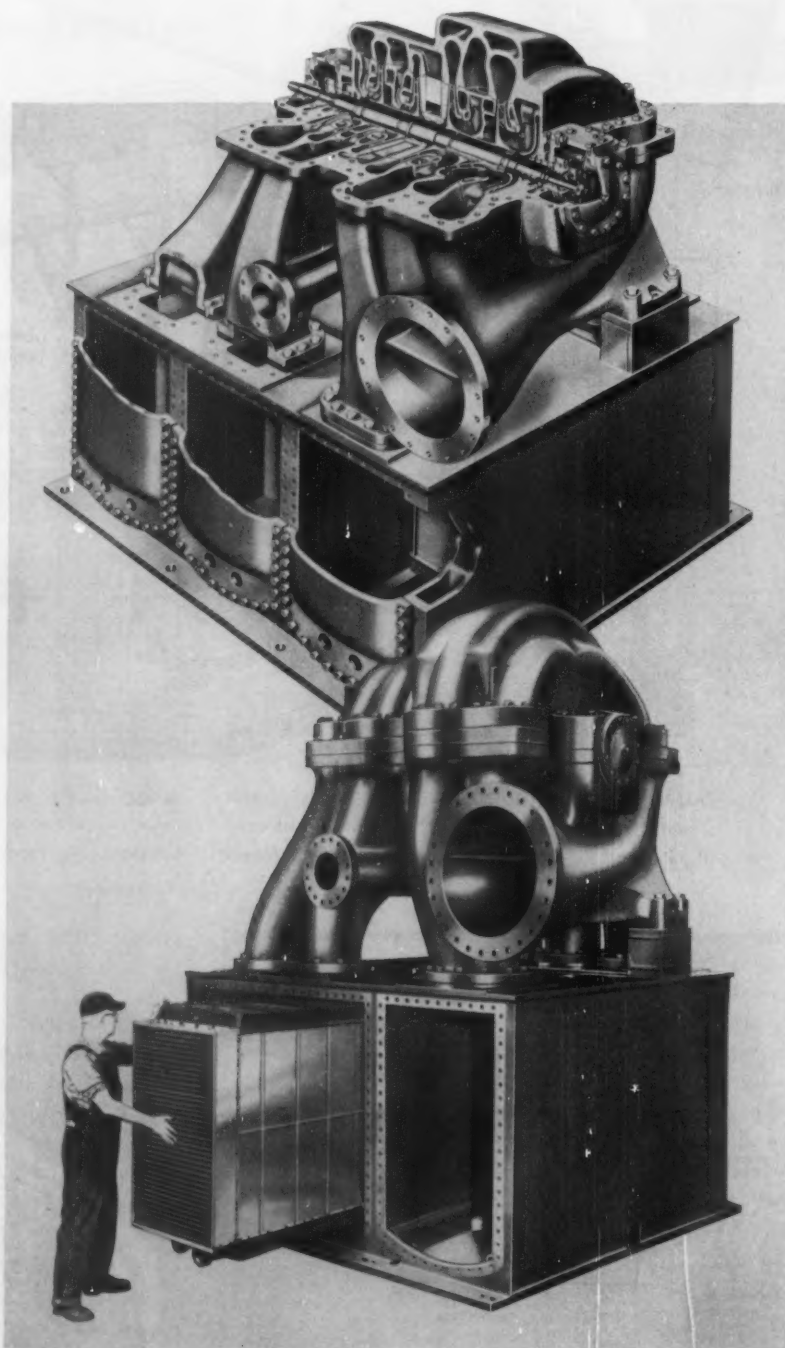
**CHOKE COILS BUCK** feed voltage that operates the vibrator. They're excited by three primary windings:

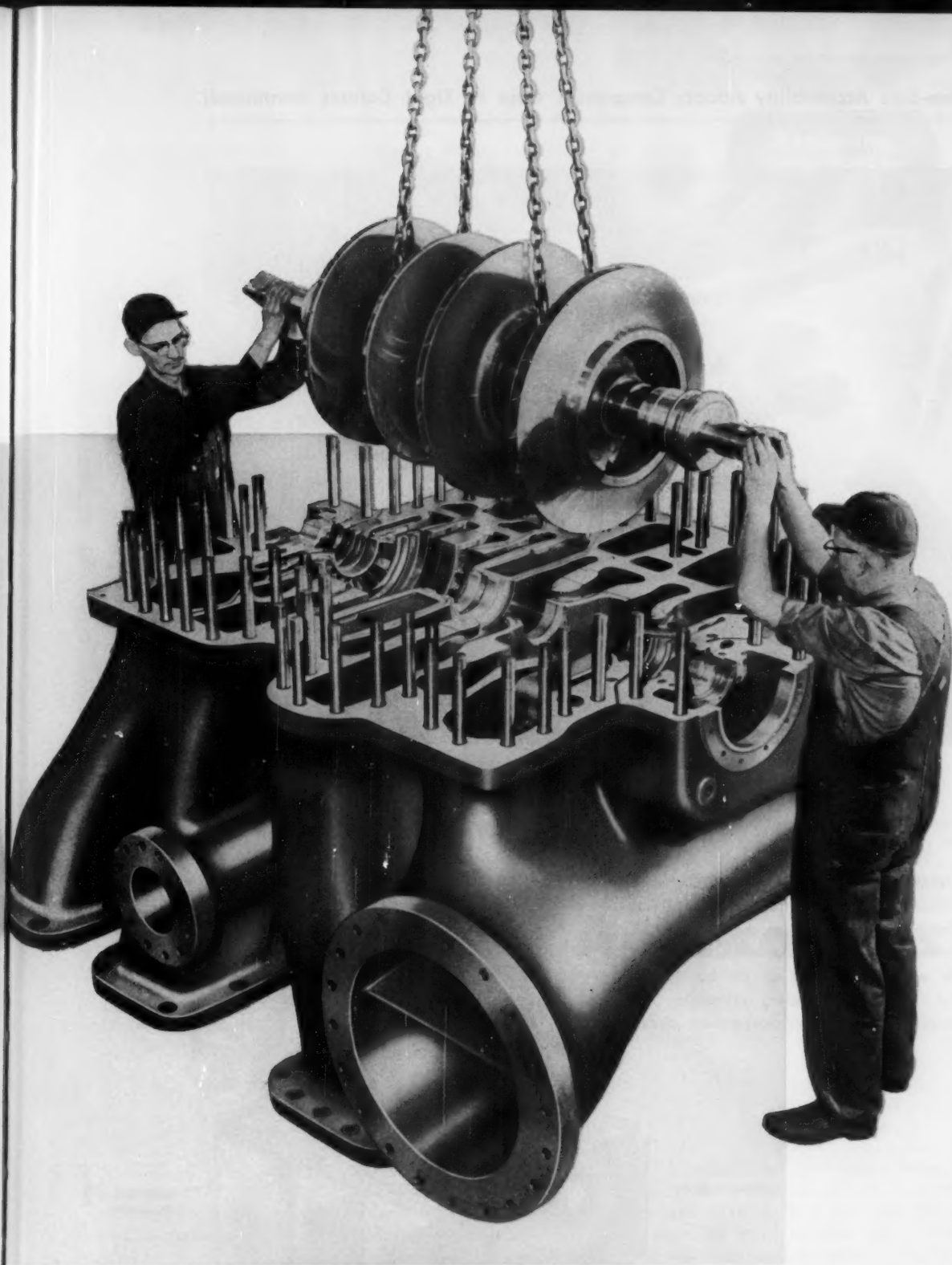
1. A voltage proportional to the line voltage causes choke coils to smooth out irregularities due to fluctuations in voltage supply.
2. A constant alternating voltage adjusted by the operator at the start of an operation sets the nominal rate of flow.
3. Input from potentiometer  $R_0$  adjusts flow rate in response to actual measured output.

Proportioning control with self-correcting servo loop was designed by Allgemeine Elektrizitäts-Gesellschaft, West Berlin.

## One-Side Accessibility Adapts Compressor Case to Tight Corners

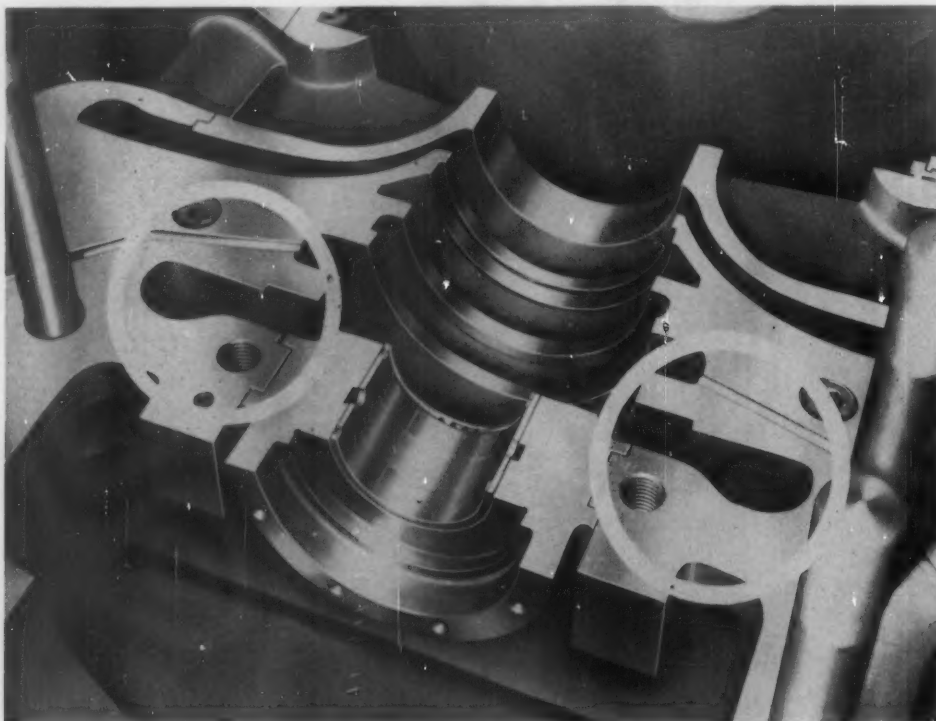
**ACCESS TO COMPONENTS** needing servicing is from one side in a new air-compressor design. Tube-and-fin inter-cooler units slide out on rails like drawers. Above them are inlet and outlet for the four-stage radial compressor. Ends are free to fit into tight quarters or to couple directly to another compressor. Moisture removers operate on a centrifugal principle as air is returned to the next compressor stage from the intercoolers.





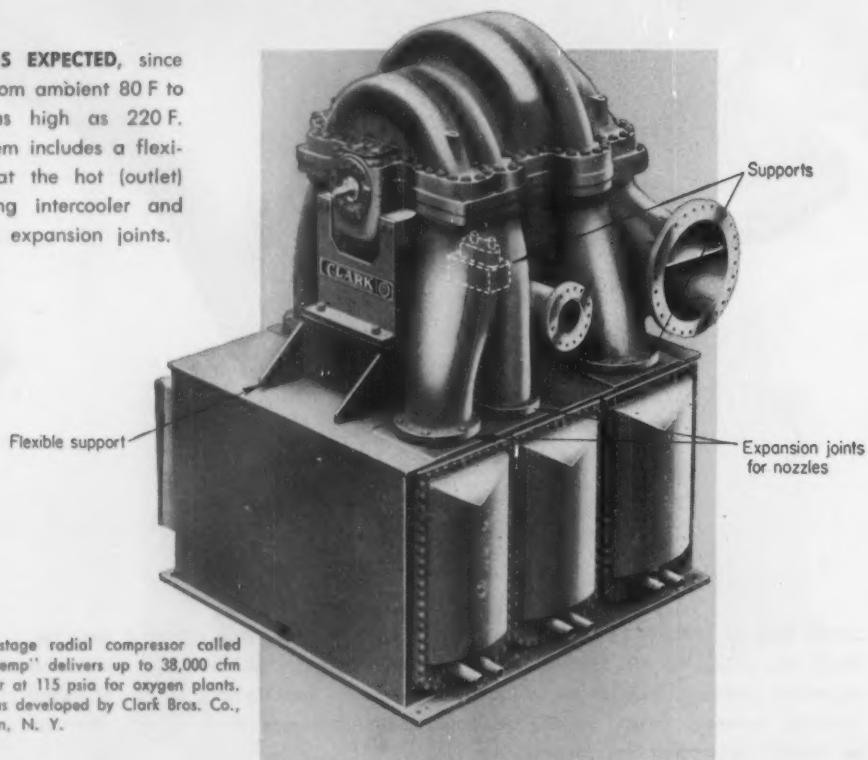
**COVER CAN BE REMOVED** to service the rotor without disturbing side piping or bearings. Single-case design permits four stages to be mounted on only two bearings, eliminating alignment problems inherent in multiple-case designs. Back-to-back design of radial impellers balances thrust, making possible smaller bearings than would otherwise be needed to support the assembly.



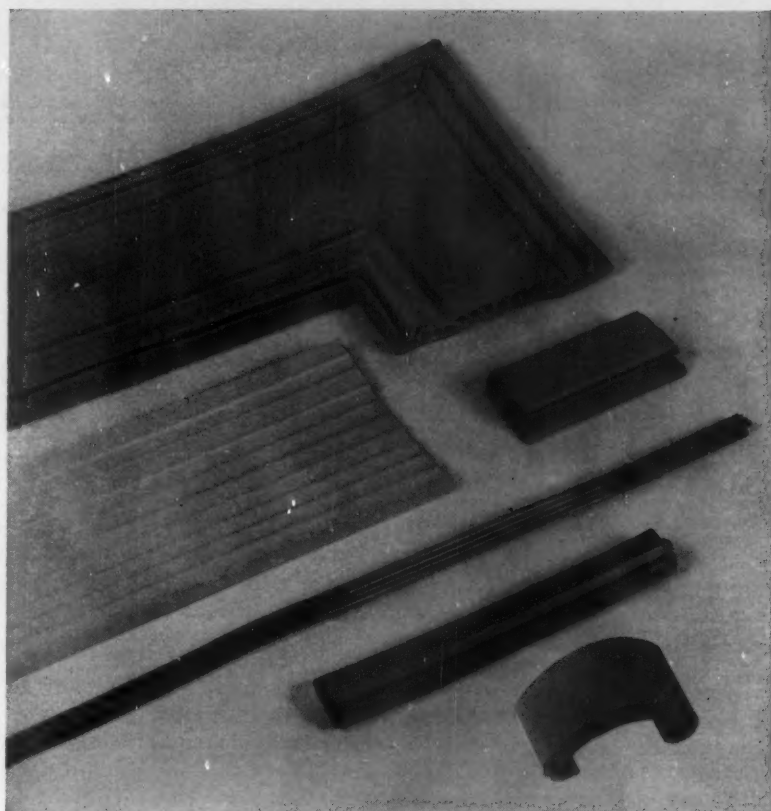


**INTERNAL BEARINGS** are isolated from compressor air in integral bearing chambers. Nonrubbing labyrinth seals protect air from oil contamination. Chamber is vented to atmosphere.

**THERMAL EXPANSION IS EXPECTED**, since temperatures may run from ambient 80 F to internal temperatures as high as 220 F. Three-point support system includes a flexible web-type support at the hot (outlet) end. Nozzles connecting intercooler and compressor stages have expansion joints.



Multistage radial compressor called "Isotemp" delivers up to 38,000 cfm of air at 115 psia for oxygen plants. It was developed by Clark Bros. Co., Olean, N. Y.



Gaskets and snap-on strips for sealing or protecting equipment make use of flexibility and color choice of vinyls.

## **Part 3**

# **Forms and Applications**

**C. W. BULKLEY**

Technical Service  
Vinyl Resins and Compounds  
Monsanto Chemical Co.  
Springfield, Mass.

**F**ORMS of vinyl chloride are almost unlimited. Because of their thermoplastic or heat-softening nature, vinyl materials can be calendered, spread coated, extruded, cast, or sprayed. They can be molded by any of several processes, or thermoformed by embossing or vacuum forming. They can be printed, heat sealed, laminated, welded, cemented, and machined. Foam and sponge materials are also made of vinyls. This article, concluding this series, describes each process and presents typical applications.

**Calendering:** Vinyl film or sheeting is calendered

by squeezing the heated plastic between a series of hot rolls to achieve the desired surface and thickness. Sheeting is material 0.010 in. thick and over. These materials are then laminated to other vinyl sheets or to different substrates such as metal, cloth, felt, or paper, or otherwise post-treated by thermoforming processes.

**Spread Coating:** Vinyl dispersions in liquid form, called plastisols and organosols, are used in spread coating. The material is metered onto metal or other substrates by passing them under a spreader knife or bar, or through reverse-roll equipment. The

## Vinyl Applications and Production Processes

Application	Other Materials	Reasons for Using Vinyl	Application	Other Materials	Reasons for Using Vinyl
<b>Calendering:</b>			<b>Injection Molding:</b>		
Light diffusers (rigid)	Glass, styrene	Economy, flame resistance.	Cord plugs, portable receptacles	Rubber, styrene, phenolics	Oil, grease, ozone, and flame resistance, flexibility, colorability.
Automotive upholstery	Leather, fabric, nitrocellulose	Economy, durability, color is through to backing.	Handle grips	Rubber, styrene, polyethylene	Pleasantness of feel, economy, oil and grease resistance.
Electrical tape	Rubber, impregnated fabric	Durability, high insulating power.	Distributor-cap nipples (automotive)	Rubber	Oil, grease, ozone, and corona resistance.
Floor covering (laminated)	Linoleum	Indentation resistance, wear and alkali resistance, style, ease of maintenance.	<b>Compression Molding:</b>		
<b>Spread Coating:</b>			Floor tile	Rubber, linoleum	Durability, oil and grease resistance, indentation resistance.
Floor covering (over roto-printed felt base)	Enamel coating	Stain resistance, toughness, special design features: sparkle, metallic glitter, etc.	Phonograph records	Shellac, styrene	Dimensional stability, shatter resistance, fidelity of mold reproduction.
Metal coating	Enamel, paint	Durability, flexibility, chemical and moisture resistance, electrical insulation.	Mounting pads	Rubber	Oil and grease resistance, damping characteristics.
<b>Extrusion:</b>			Printing plates	Metals	Economy, light weight.
Insulating tubing (electrical)	Rubber	Good insulation characteristics, reusability, oil resistance.	Pipe fittings	Metals	Economy, light weight.
Hose, tubing	Rubber	Oil, grease, chemical, ozone and abrasion resistance.	<b>Slush Molding:</b>		
Bumpers, guards	Rubber	Good damping and shock-absorbing characteristics.	Balls, floats	Rubber, metal	Chemical resistance, economy.
Tubing (special heat-shrinkable material)	.....	Flexibility, abrasion resistance, ability to shrink to tight fit.	Tool grips	Rubber	Insulation, pleasant feel.
Gaskets (refrigerators, etc.)	Rubber	Economy, durability, grease resistance, colorability.	Wire-basket coating	Enamel	Crack resistance.
Pipe	Metals, glass, ceramics	Economy, light weight, corrosion and chemical resistance.	Marine fittings (coated)	Zinc, chrome, rubber	Colorability, corrosion resistance.
Wire insulation, cable jacket	Rubber, lead, polyethylene, paper	Toughness, heat, flame, oil, grease, moisture and sunlight resistance, economy, high dielectric strength.	<b>Blow Molding:</b>		
Conductive shielding	Copper braid	Flexibility, economy, tight fit through air or liquid-tight enclosures.	Bottles, tubes	Polyethylene	Resistance to certain oils and cosmetics.
Underground feeder	Lead	Economy, resilience and crush resistance.	<b>Thermoforming:</b>		
			Automotive upholstery (embossed)	Fabric, leather	Durability, heat sealability, cleanability.
			Contour maps (vacuum formed)	.....	Colorability, durability.
			<b>Foam and Sponge:</b>		
			Packing, shock-absorbing and insulating materials	Rubber, urethane	Cushioning effect, good damping.

plastic is then heated to thermoplastic-melt form, and cooled to a smooth surface. Compared with calendering, this process is more economical for short runs. Adhesion depends on the texture and composition of the substrate.

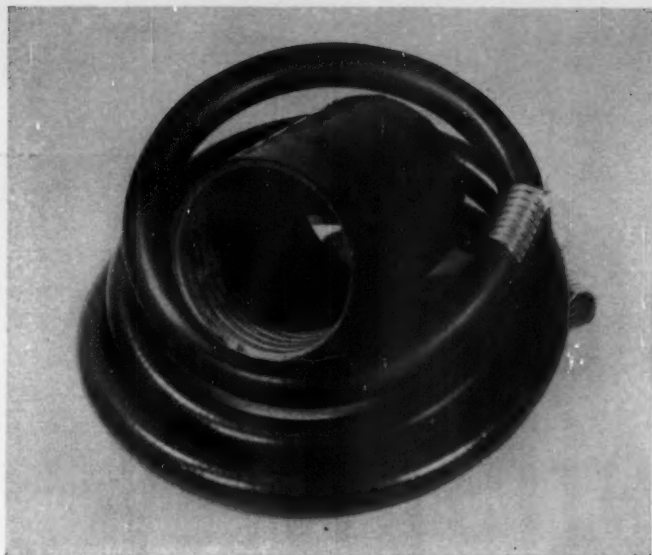
Unsupported cast film or sheet can be stripped from glazed paper or stainless-steel carriers. But direct spread coating on the substrate eliminates a laminating step and produces better adhesion in most cases.

**Extrusion:** Vinyl pipe, hose, tubing, and moldings are readily made by conventional extrusion methods. Film and sheeting also can be extruded

by using either a flat die, or a circular die and stretching the resulting tube by air pressure.

Coating of wire and cable accounts for the greatest single vinyl extrusion application. A crosshead is used, through which the wire is pulled, usually at a right angle to the axis of the screw. Plastic enters the crosshead, surrounds the wire or cable, and emerges from the die as a controlled-thickness coating.

**Injection Molding:** Complex shapes can be produced rapidly and economically by injection molding. The melted plastic is forced through a nozzle into a closed mold at pressures in the range of 15,-



Vinyl tubing, extruded over flexible metal hose, produces liquid-tight member for equipment with moving parts.

000-20,000 psi. Flexibility and memory of plasticized PVC permits removal prior to complete cooling and allows design of parts with deep undercuts or with large, irregular, removable inserts.

Size is normally limited to about 2 lb. Most successful products are under 8 oz in weight, except for industrial parts such as pipe fittings and valve bodies where surface finish is not critical.

**Compression Molding:** Although the process requires longer cycle times than injection molding, compression molding is economically justified where very large pieces or a multiplicity of small, shallow pieces are involved. Or when laminar structure is desired, using reinforcing sheets.

In compression molding, a measured quantity of vinyl compound is charged into an open mold. The mold is then closed and heated, then cooled. During the heating cycle, high internal pressure is applied, causing the material to flow to match the mold cavity.

Multicolor parts requiring sharpness of lines or color definition are usually produced by compression molding. Thick slabs can be molded with multicolor or terrazzo designs, or with pearlescent, metallic, striped, or mottled effects. The slabs are then sliced or sheeted.

**Slush Molding:** The liquid plastisol form of vinyl is used in slush molding to form relatively thin-walled objects. The liquid is poured into a hot metal mold which gels the material near the metal. The balance is poured out after the desired thickness has gelled. A heat cycle then converts the weak wall to a fully fused thermoplastic melt, which cools to a tough, rubber-like product.

Rotational casting is a special form of slush molding, whereby hollow molds are charged with a weighed amount of plastisol, then rotated on two axes while being heated. Hollow objects such as balls and floats are made by this method.

Solid objects can be cast by merely pouring plas-

tisol into molds, then heating. Dip molding is like slush molding except that male molds are used. In most cases the object is covered with a thick coating; thin vinyl coatings are sprayed.

**Blow Molding:** A process that combines extrusion and compression molding, blow molding is used for thin-walled products. A mold is closed around an extruded tube of plastic, sealing off the open end of the tube. Compressed air is then introduced into the tube and the hot plastic conforms to the shape of the mold.

Another technique seals the edges of sheets of plastic together in a closed mold and introduces air through a thin tube or needle. The latter process usually requires hot and cold mold cycling.

**Thermoforming:** Techniques of thermoforming take advantage of the thermoplastic nature of vinyl-chloride plastics. In vacuum forming, a sheet of plastic is heated and then drawn into a mold cavity by vacuum, applied through many small holes. When a male mold is used, the term "drape forming" applies. When deep-draw vacuum forming is done, a "plug assist" method mechanically forces the sheet part of the way into the mold to minimize thin spots in the finished piece.

Embossing is usually done by passing hot plastic film, sheeting, or strip through a pair of rolls, one of which bears the three-dimensional pattern desired, the other being a rubber backing roll.

**Foam and Sponge:** To make vinyl foam or sponge, a chemical blowing agent is used, which releases gas by decomposition at a predetermined temperature. This agent is mixed into a vinyl plastisol in the compound's liquid stage. Open-cell foam is produced when the plastisol is fused by heating in an open mold or without high-pressure buildup. Closed, high-pressure molds are used for closed or unicellular foam. The final density is controlled by formulation and can be as low as 5 lb per cu ft.



# Predicting Reliability

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and

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**R**ECENT emphasis upon reliability of devices, especially those designed for aero-space applications, has given rise to much investigation into this challenging and relatively young field.<sup>1,2,3</sup> Reliability poses the fundamental question: What is the probability that a device will function within its design parameters for a specified life?

The solution to this problem lies in somehow quantifying basic design parameters of a device and deriving index numbers which can predict its relative utility. Forecasting reliability depends upon knowledge of the limiting factors that tend to impose restrictions upon the functional characteristics of a device before it is actually constructed and put in service. It seems reasonable that the more *a priori* knowledge available the better will be the correlation between an estimate and actual performance.

Here then is the prime issue: Knowledge of basic design parameters may be transformed into mathematical terms to appear as predictor variables in a predictor model. Because the prediction problem is essential to reliability, ideal prediction equations should satisfy the requirements listed in Table 1.

The practical consequences of developing prediction techniques that closely approach the ideal are manifold both to the design engineer and to the buyer. It is now common for the buyer in space-age

projects to stipulate reliability requirements, and often he awards contracts on the basis that the designer can show his capability to meet these requirements.

Moreover, valid reliability-prediction techniques are additional design tools with which a designer can evaluate preliminary proposals and estimate his capacity to meet over-all systems reliability requirements and to determine exactly which subsystems might require concerted effort to achieve reliability obligations.

With prediction techniques at his disposal, he could also determine immediately and objectively the value of cogent design changes. Unquestionably, prediction techniques so utilized would result in reduced prototype and production costs and in assuring delivery schedules.

Today the designer must not only face the challenge of obtaining high inherent reliability in his original concept but must also be aware of the probability that people will handle the product from initial production to final use. Moore states:<sup>4</sup> "Inherent reliability is the potential reliability present in the physical article when manufactured to a completely mature design with no degradation due to fabrication and assembly. Once the design of a device is released, the inherent reliability is established, and successive steps in manufacturing, inspection, test, packaging, storing, transportation, service,

<sup>1</sup>References are tabulated at end of article.

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Designing for required performance and life is no new assignment. But 100 per cent success of a total system has never been easy to achieve. Today, with bigger and more complex systems, the job is even tougher—and the cost of failure can become staggering.

Experience—from test and service—provides a basis for estimating the probability of success and plotting courses toward improvement. The problem is how to formulate experience into a useful predictive tool.

Three methods are presented here. Two have been developed in recent years and rather widely applied. The third—relative-utility evaluation—is a proposed new method for predicting reliability.

and maintenance can only maintain or degrade the reliability of that device.”

This article has two objectives: To describe the state of the art of predicting reliability via outlines of several current techniques, and to present a new technique that is still speculative but, yet, is supported by the results of studies in some fairly substantial and complex projects.

Current techniques reviewed here are the use of a standard and the use of rating factors. The new concept to be propounded and developed is called *relative-utility evaluation*.

### Predicting Reliability by Using a Standard

One component is selected as the basic predictor variable in the “standard” method of predicting reliability. It is arbitrarily assigned unity value. For example, one technique defines the vacuum tube as *unity-complexity factor*. See *Definition of Terms*. All other components in the same system—capacitors, resistors, motors, servovalves—are rated to this standard by some comparative means. For instance, mean-life ratings or mean-time-between-failures rates are compared. These comparative rates are generally called *relative-complexity factors*. No attempt is made to distinguish one type of subsystem from another by function, such as electronic, hydraulic,

mechanical. Hence, all similar components have equal relative-complexity factors (RCF) regardless of which system they function in.

To illustrate how this technique is put into practice, examine a system containing two vacuum tubes, three resistors, two capacitors, one transformer, and one servovalve. Previous information shows that these components have equivalent vacuum-tube ratings as follows: 0.5 for resistors, 0.3 for capacitors, 2.3 for transformers, and 6.0 for servovalves. Simply summing the product of the equivalent ratings and the number of components leads to a relative-complexity factor of 12.4:

$$RCF = 1.0(2) + 0.5(3) + 0.3(2) + 2.3(1) + 6.0(1)$$

If this package were only one of several in a complete system, all others would be rated in the same manner, and ultimately a total system complexity factor would be established.

Two important assumptions, not always explicit, are made here: 1. The true relative-complexity factor is derived by the additive process of all component parts, rather than some other process, such as multiplicative. 2. The total system complexity factor is also an additive process of all subsystem relative-complexity factors. These assumptions stem from the current reliability concept that a system and its associated subsystems may be transformed into an equivalent series circuit or a chain of packages. Failure of any one element in the circuit, or any package in the chain, results in failure of the entire system.

Reliability-requirements attributes may be assigned to each subsystem by simple proportionality on the further assumption that the total reliability of the system is equal to the product of the reliabilities of all the subsystems. In this case, reliability is defined to be inversely proportional to the relative-complexity factor. The implication is that the reliability of each subsystem is an independent variable in the total system function.

This method achieves moderate success. It should be noted that it is nonobjective; it requires much engineering judgment and is idiosyncratic to the extent to which it would not be repeatable at another time. This technique does not meet the requirements of the ideal, Table 1. Generally, it fails to

**Table 1—Requirements of Ideal  
Prediction Equations**

1. Predictor variables should be derived from simple, elemental design variables.
2. Prediction variables should be objective.
3. Predictor equations should forecast malfunctions or other forms of reliability information with statistical assurance (of the order of 0.05 level of confidence).
4. Predictor equations should be applicable to different types of devices (electronic, pneumatic, hydraulic, etc.)
5. Predictor equations should provide means for evaluating design at any stage in its evolution.

## PREDICTING RELIABILITY

satisfy requirements 1, 2, and 3 and only occasionally can it be expected to meet requirement 4.

### Predicting Reliability by Using Rating Factors

A number of elemental parameters are selected for predictor variables which may or may not be reduced into one predictor variable in the rating-factor method. The most popular method is to build up a given package into a relative-complexity factor by summation of its component parts. As in the first method, once a package or subsystem has a relative-complexity factor established, the same procedures are followed to derive reliability-requirements attributes and its reliability. The major difference between the two methods lies in the scoring of components. There are many variations in both the choice of predictor variables and in the selection of the score range of values. One variation is to list a set of parameters, such as:

1. Number of machine processes required to manufacture a component.
2. Number of subcomponents in the component.
3. Environment uprating or derating.
4. Mean life.
5. State-of-the-art advancement.

An example is a ball bearing. The following information is known about it:

1. It requires 15 machine processes.
2. It contains 20 subcomponents.
3. It will operate at maximal environmental conditions for one-half of its mission time.
4. It has a mean life of 1000 hours.
5. It contains materials well within the state of the art.

According to a set of previously established ground rules for determining component scores, the relative-complexity factor of this ball bearing would be obtained as follows:

1. Number of machine processes	= 15
2. Number of subcomponents	= 20
3. Derating factor for environmental conditions: 3 times number of machine processes	= 45

## Definition of Terms

In the field of reliability, there is often confusion of terminology. Four terms that are basic to the scope and problems of reliability are defined and discussed here.

**Reliability:** The probability that a device will function within its design parameters for a given life. The design parameters are boundaries of functional utility and include operational environment, maintenance and service requirements, safety, cost, configuration, and time.

**State of the Art:** All of the technological and scientific advancements which are incorporated into the device at any particular stage of research, development, production, or service of a device. These advancements include the configuration, all the skills and knowledge available to produce the device—materials, production tools, manufacturing processes, manpower skills and arts, degree of industrialization (complexity), etc. The state of the art describes the extent to which any device is functional.

**Complexity:** One of the many states of a device, particularly that utility attribute which describes the degree to which the various subparts interact with each other. Complexity also implies the inherent difficulty of determining operational characteristics. Complexity is more than the sum total of the number of parts incorporated into a device. It is all of the ways in which these components interact to accomplish the de-

sign mission, and it is all of the ways the device may be utilized, either favorably or otherwise. Complexity, in the broad sense, tells how far our technology has advanced. The ancient rock-throwing catapult compares equally with the device used for launching aircraft from the deck of a ship, as far as the complexity of the launching principle is concerned, but there is a great difference in the complexity of the control mechanisms.

**Relative-Utility Factor:** The term, *relative-complexity factor*, is sometimes used interchangeably with *complexity* or *relative complexity*. To avoid confusion because of the connotation of *complexity*, adoption of *relative-utility factor* is suggested. Relative-utility factor is defined as a measure of equipment performance, when the performance of one equipment is compared with other equipments functioning within the same system. A relative-utility factor tells how well a device can be expected to function; the degree to which it satisfies its expected performance requirements depends solely upon our individual criteria for judging these characteristics.

As an illustration of how these terms are related, examine a system composed of two common household devices: 1. A toggle switch controlling the operation of 2. An incandescent lamp. For our purposes, neglect the electrical wiring and the lamp socket. In function, both devices allow the passage of electricity when "on." The toggle switch has a

spring-lever mechanism in contrast to the filament of the lamp.

One would say that the toggle switch has a greater complexity than the lamp because it has moving parts. For the moment, how much the respective complexities differ is of no concern—only that there is a difference.

Before relative-utility factor can be discussed, some criterion for performance must be set. Suppose the number of on-off cycles is used. Then, common experience would suggest that the lamp would fail prior to the failure of the switch if two new devices in this system were tested by repeated on-off cycling. Hence, by the foregoing definition and discussion, the switch would have a better relative-utility factor for this characteristic.

It seems reasonable to indicate better performance by a lower number. Thus, in this example, the switch would have a lower relative-utility factor number than the lamp.

The fundamental idea here is that high complexity does not imply *ipso facto* low relative-utility factor. A complex mechanism does not in itself mean that it cannot function. As a matter of fact, it is possible to achieve greater performance (lower relative-utility factor) without changing the complexity of the device. Common examples: A cigarette lighter that lights in a full gale, ball-point pens that write over grease, and the latest revision of a jet engine.

• • •

- |  |       |
|--|-------|
| 4. Mean life factor, based on 500 hours mean life, minus 2 times number of processes                             | = -30 |
| 5. State of the art factor, assuming 1.5 margin of design integrity, minus 1.5 times number of machine processes | = -23 |
| Total ball-bearing relative-complexity factor  | = 37  |

Estimates 3 and 5 are based on judgment and personal experience of the engineer performing the rating.

Another variation is to list all of the components in the subsystem and then have a group of engineers score each component according to a definite scoring plan. As an example of this method, consider a subsystem containing these components:

1. Fixed carbon resistors
2. Variable wire resistors
3. Ceramic capacitors
4. Paper capacitors
5. Audio frequency transformers
6. RF coils
7. Diode vacuum tubes

To simplify this example, ratings and operating characteristics of these components are not given here. However, in actual practice, these facts are important and necessary for the rating engineers. To continue, this list is given to two sets of ten different engineers (the larger the number of engineers the better) and each one is asked to rate every component within a scale of 1 to 100. The higher the number the less "reliable" the component. Judgment criteria may or may not be set up. In addition, this list might be given to a third set of ten engineers as a control measure. Each of them would be asked to rank-order each of the components from 1 to 7, where 1 is the most reliable. With the resulting data, two choices would be available for assigning relative-complexity factors:

1. Choose an average value from the obtained data from the two sets of rating engineers using a centesimal scale, thus:

- |                              |      |
|------------------------------|------|
| Fixed carbon resistors       | = 5  |
| Variable carbon resistors    | = 15 |
| Ceramic capacitors           | = 3  |
| Paper capacitors             | = 10 |
| Audio frequency transformers | = 40 |
| RF coils                     | = 25 |
| Diode vacuum tubes           | = 97 |

2. If there is statistical significance of correlation between the data from two sets of rating engineers and the control set of rating engineers, use rank-order values:

- |                              |     |
|------------------------------|-----|
| Ceramic capacitors           | = 1 |
| Fixed carbon resistors       | = 2 |
| Paper capacitors             | = 3 |
| Variable carbon resistors    | = 4 |
| RF coils                     | = 5 |
| Audio frequency transformers | = 6 |
| Diode vacuum tubes           | = 7 |

Regardless of the choice, each component is identified by a number which in turn lends itself to the concept of relative-complexity factor. In general, there is not too much deviation between the different

techniques, once the relative-complexity factor is established, in the successive procedures to determine reliability requirements and also to make reliability predictions.

Using rating factors to predict reliability produces about the same degree of success as using a standard—the first method—and meets the requirements of the ideal method no better or worse.

## Predicting Reliability by Relative-Utility Evaluation

The concept of relative-utility evaluation is here proposed for the first time. It embodies a method for measuring the relative merit of one thing in respect to another, wherein merit, in this particular sense, implies functional worth, or simply, utility.

Different utility attributes may be desired by different groups, and resulting confusion seems unavoidable. Similar devices may be marketed by different sources and may have many different applications. A given resistor may go into a missile rudder-control package, a radio transmitter, a medical test apparatus. The designer is particularly interested that the device will respond to certain inputs and function correctly to give certain allowable outputs when employed in a given environment. The manufacturer views the device in light of man-tool processes necessary for its production. Maintenance people emphasize its value in respect to ease of repairs and operation. And so, each one who has contact with the device has a different set of utility values for it.

However, it is probable that there is a common set of denominators which tie all utility attributes into one "conceptual bundle." If such is true then it is possible to evaluate the majority of attributes ascribed to the device by analyzing and understanding the mechanism of the conceptual bundle.

Here the thesis is that such a set of common denominators exists and is comprised of simple, elemental, original design variables (or design parameters).

The foundation of this theory is the observation: All functional equipment design improvements tend toward minimization of configuration and cost of production. Improvements may be generated in many ways: Incorporating latest information from the research of new or esoteric materials and industrial processes, closing the feed-back loop between field operations and design reviews, increasing engineering ingenuity and inventiveness in basic design concepts. Regardless of the source or method, these improvements reflect ultimately in discrete values of cost and configuration changes in the equipment. From these notions is developed a prediction technique which is directly applicable to reliability studies and which meets all of the requirements set forth for the ideal technique.

This particular technique has merit in measuring the relative value of subsystems within the total framework of an over-all system and does not function, or explain the interactions, between systems. A preliminary mathematical model is presented, based



## PREDICTING RELIABILITY

on information concerning the relative frequency of malfunctions due to parts failure in a set of subsystems within a guided-missile system.

Predictor variables used in the predictor equations are the elemental design parameters of *cost*, *weight*, and *volume* of the individual subsystems under investigation. Although it is not necessarily relevant to the problem of prediction to know why a set of predictor variables work, it is satisfying when there is an underlying rationale conforming to common experience. The rationale of these particular predictor variables, as presented here, may stimulate further research into this area.

**Technique and Rationale:** Cost, weight, and volume—the predictor variables—are combined in this empirical equation:

$$K = \text{cost} \times \text{weight} \times \text{volume} \quad (1)$$

where  $K$  = predictor factor.

Using this equation leads to high correlation between subsystems with high  $K$  (predictor) factors and high numbers of parts failures within the corresponding subsystems.

What are the reasons for selecting these particular predictor variables?

**Cost:** Generally, the earlier on the learning curve, the higher the unit cost of production. When an item is novel, information is meager not only about its production and operational characteristics, but also about the necessities of handling and maintenance. As knowledge increases—as equipment undergoes debugging—it is reasonable to expect that the unit cost of production will diminish. True, even a minor improvement late in a production schedule becomes extremely costly to incorporate. However, all things considered, the later models tend to have a lower unit production cost.

**Weight and Volume:** Engineering advances usually come along more than one dimension. A current trend in good engineering practice is the improvement of materials—particularly the constant search for stronger and lighter ones to replace the old. Relatively heavy devices are likely to cost more and to be more difficult to fabricate, package, transport, and maintain in service. In airborne and space systems, weight must be reduced to increase payload. At present, and for some time to come, the more advanced a device the less it is likely to weigh. Usually concomitant with a decrease in weight of a device is an increase in the degree to which it is well-designed in terms of ruggedness, maintainability, resistance to hostile environments, and a host of other factors which influence the likelihood of error.

In electronic equipment, for example, the general trend is toward miniaturization, with subsequent reduction in both weight and volume. Smaller components tend to be less fragile and to require less difficult maintenance procedures, not necessarily as

a result of miniaturization, *per se*, but often simply as a result of other engineering improvements. Not only is a transistor smaller and lighter than a vacuum tube, but generally, it is less easily damaged both physically and electronically. Similarly, new strong and lightweight materials are benefiting mechanical design.

**Methods and Results:** Twelve subsystems of a ground-to-air guided missile system were studied. Cost, weight, and volume of each subsystem were obtained. Each subsystem was carefully studied for function and then was designated either mechanical or electronic on the basis of the majority of its components. With Equation 1, predictor factors  $K$  were computed. Then, for each of the 12 subsystems, the number of parts failures that were charged to these subsystems during the period December 8, 1958, through June 30, 1959, were totaled.

Table 2 shows the major and minor causes which were defined as parts failures by line supervisors and reliability engineers. Whenever a malfunction occurred it was recorded and coded on IBM cards and charged to the subsystem as a parts failure according to the list in Table 2. Failures were associated with a missile, or product, which was in early R & D stages with portions in various phases of design, test, mock-up, production, and field service.

The  $K$  predictor factors for the subsystems were then rank-difference correlated with the numbers of parts failures charged to the subsystems, as shown in Table 3.

Fig. 1 shows the plot of the rank order of the  $K$  predictor factors against the rank order of the number of parts failures charged to the corresponding subsystems. The ideal regression line has a slope of +1. In comparison the correlation line of the plot has a slope of +0.56. Scores for mechanical and electronic subsystems are plotted together inasmuch as there is an interaction between systems. When plot-

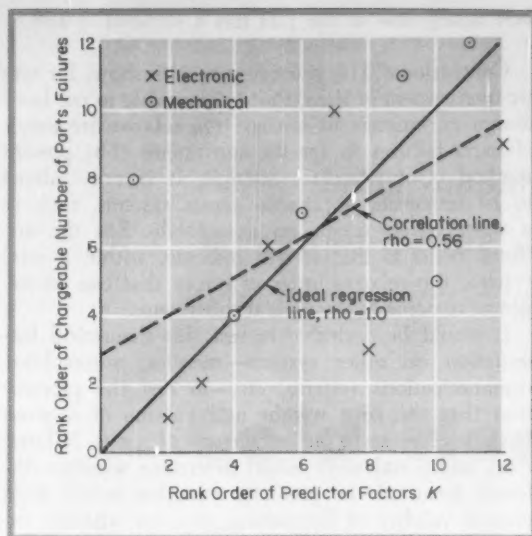
**Table 2—Parts Failures Charged to 12 Subsystems of an Air-to-Ground Missile System**

### Major Causes

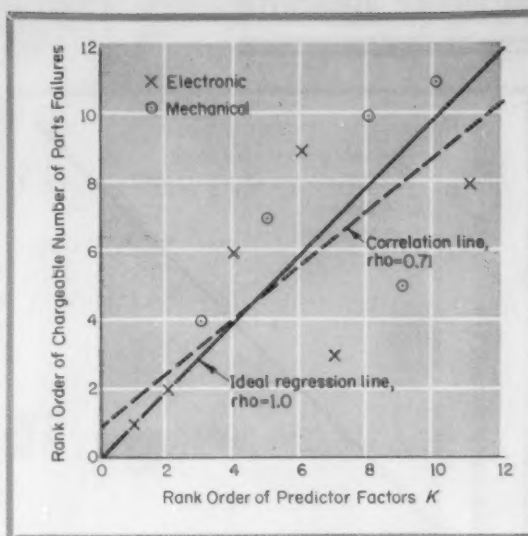
1. Faulty part, module or package
2. Faulty tube
3. Part or equipment failure, wear-out
4. Adjustment required due to drift
5. Part or equipment failure, degradation

### Minor Causes

- |                               |                           |
|-------------------------------|---------------------------|
| 6. Dimension                  | 25. Drift                 |
| 7. Tolerance                  | 26. Mechanical deficiency |
| 8. Index or mating part       | 27. Open                  |
| 9. Conflict                   | 28. Short                 |
| 10. Lubrication               | 29. Noise                 |
| 11. Sealing                   | 30. Leakage               |
| 12. Heat                      | 31. Chatter               |
| 13. Insulation                | 32. Improper contact      |
| 14. Cooling                   | 33. Insulation breakdown  |
| 15. Locking                   | 34. Resistance            |
| 16. Contamination             | 35. Inductance            |
| 17. Age limitation            | 36. Current               |
| 18. Clearance                 | 37. Voltage               |
| 19. Bonding or grounding      | 38. Electrical leakage    |
| 20. Shielding                 | 39. Transconductance      |
| 21. Operating environment     | 40. Unstable              |
| 22. Impact                    | 41. Inoperative           |
| 23. No confidence replacement | 42. Accumulated tolerance |
| 24. Welding                   |                           |



1 Scatter plot of rank order of predictor factors  $K$  versus rank order of chargeable number of parts failures associated with 12 subsystems in air-to-ground missile system.



2 Scatter plot of rank order of predictor factors  $K$  versus rank order of chargeable number of parts failures associated with 11 subsystems in air-to-ground missile system.

Table 3—Correlation Data for 12 Subsystems  
Dec. 8, 1958, to June 30, 1959

Sub-system	Type*	Predictor Factor, $K$	Rank Order of $K$	Parts Failures	Rank Order of Parts Failures
A	m	19105	1	45	8
B	e	10366	2	624	1
C	e	6976	3	330	2
D	m	4456	4	227	4
E	e	466	5	101	6
F	m	452	6	52	7
G	e	244	7	36	10
H	e	73	8	238	3
I	m	31	9	33	11
J	m	17	10	157	5
K	m	15	11	6	12
L	e	9	12	44	9

\*m=mechanical subsystems, e=electronic subsystems

Table 4—Correlation Data for 11 Subsystems  
Dec. 8, 1958, to June 30, 1959

Sub-system	Type*	Predictor Factor, $K$	Rank Order of $K$	Parts Failures	Rank Order of Parts Failures
B	e	10366	1	624	1
C	e	6976	2	330	2
D	m	4456	3	227	4
E	e	466	4	101	6
F	m	452	5	52	7
G	e	244	6	36	9
H	e	73	7	238	3
I	m	31	8	33	10
J	m	17	9	157	5
K	m	15	10	6	11
L	e	9	11	44	8

\*m=mechanical subsystems, e=electronic subsystems

ted separately, they still yield positive correlations ( $t = 3.22$  for electronic, significant at 0.025 level;  $t = 1.54$  for mechanical, not significant at the 0.05 level, for four degrees of freedom).

The Spearman rank-difference correlation was used to test whether the relationship between the  $K$  factors and the chargeable parts failures was positive and statistically significant. This coefficient was used mainly because it is a product-moment coefficient of correlation<sup>5</sup> and it is not influenced by the large range shown by the variables. The obtained Spearman rho of 0.56 indicated that there is a strong positive relationship between the  $K$  factors and the chargeable parts failures associated with the corresponding subsystems. To test the variability, sample size, and the magnitude of the Spearman rho correlation, a " $t$ " test was made.<sup>5</sup> The obtained  $t$  was equal to 2.14 with ten degrees of freedom and is significant beyond the 0.05 level of confidence. Hence, the null hypothesis, that the correlation is fortuitous, is rejected.

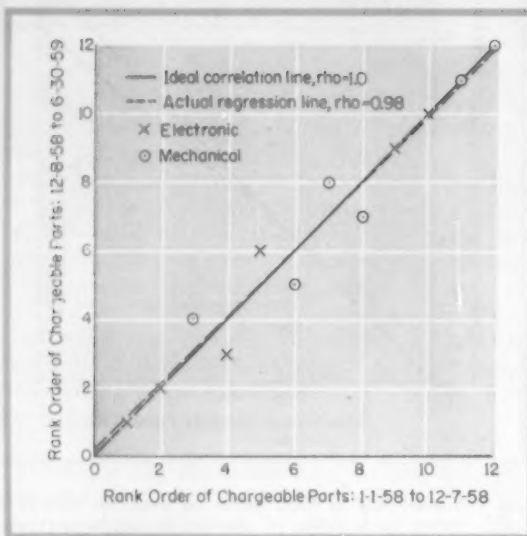
Table 3 shows that subsystem A has rank 1 as

predictor factor and rank 8 as chargeable parts failures. A study was made to determine why there is such disparity between ranks. It was found that unlike other subsystems which could be tested by measuring input and response over the working range, subsystem A was not given a complete functional check, only a thorough examination for proper installation. Determination of all possible parts failures was limited to only certain types of controls and valves during this phase of the testing program. The true test was in actual flight, for which malfunction data are not included in this study.

As a matter of interest, subsystem A was excluded and the 11 remaining subsystems were tested for correlation. The Spearman rho obtained is 0.76 and the  $t$  equals 3.63, for nine degrees of freedom, yielding statistical significance beyond the 0.005 level, Table 4. Again both mechanical and electronic subsystems were plotted jointly. When plotted separately, both types of subsystems yield  $t$  significant beyond the 0.025 level.

Fig. 2 shows the plot of the rank order of the  $K$

## PREDICTING RELIABILITY



3 Scatter plot of chargeable parts failures over one period versus those over a different period for 12 subsystems in air-to-ground missile system.

Table 5—Parts Failures for Two Periods

Sub-system	Type*	Parts Failures 1-1-58 to 12-7-58	Rank Order	Parts Failures 12-8-58 to 6-30-59	Rank Order
A	m	141	7	45	8
B	e	811	1	624	1
C	e	592	2	330	2
D	m	411	3	227	4
E	e	269	5	101	6
F	m	97	8	52	7
G	e	70	10	36	10
H	e	371	4	238	3
I	m	53	11	33	11
J	m	163	6	187	5
K	m	10	12	6	12
L	e	98	9	44	9

\*m=mechanical subsystems, e=electronic subsystems

factors against the rank order of the chargeable parts failures for 11 subsystems. The best fitting line of the plot has a slope of 0.76 (ideal = 1).

From this exercise, it is apparent that subsystem A was not a true member of the population. Or, it is likely that for mixed subsystems (structural-mechanical, mechanical-electrical, mechanical-chemical, etc.) other equation forms would be more applicable.

To check the stability of the criterion, parts failures chargeable to each of the 12 subsystems for the period of December 8, 1958, to June 20, 1959, were rank-difference correlated with the same systems for the year 1958, through December 7, 1958. The Spearman rho = 0.98 and  $t = 15.9$ , for ten degrees of freedom, which is highly significant, beyond the 0.005 level of confidence, Table 5. The criterion, therefore, appears quite stable as shown in Fig. 3. The ideal regression line has a slope of +1, the

best fitting line of the plot has a slope of +0.98.

**Conclusions:** The preceding results show, for one weapon system at least, that it is possible to use basic design parameters to forecast the relative frequency of parts failures in specific subsystems. The present method is only a first attempt. It is not claimed to be universal, applicable across systems, such as a wrist watch versus an automobile. But the authors' belief is that it will indicate, within a total system, the relative order of errors that can be expected to occur in the several subsystems.

It would be desirable to test this theoretical formulation on other systems—missiles, automobiles, communications systems, etc.—to test the proposition that the cost, weight and volume of a given package can serve as predictors of parts failures. Also, additional work might determine whether different forms of the predictor equation would yield greater validity of forecasting, or even whether inclusion of other elemental variables with the present ones would enhance its usefulness.

The present authors suggest that a general equation would have the form:

$$K = (\text{cost})^a (\text{weight})^b (\text{volume})^c \quad (2)$$

where  $a$ ,  $b$ ,  $c$  are constants to be determined.

This method offers a potential tool to quantify and to predict the likelihood of parts failures within a given system chargeable to the individual subsystems. The method might also well be used to determine the merit of redesign or proposed design changes to minimize the probabilities of parts failures: The  $K$  factor of the first design could be compared with the  $K$  factor of the follow-on design and a rough indication obtained as to the extent parts failures might be reduced.

Finally, it is the hope that this method will lead to other research on the much needed ability to forecast all types of malfunctions.

## REFERENCES

1. C. R. Knight and E. R. Jervis—"A Discussion of Some Basic Theoretical Concepts, and a Review of Progress Since World War II," ARINC Monograph No. 1, Aeronautical Radio Inc., Washington, D. C., 1955.
2. R. Lusser—"The Notorious Unreliability of Complex Equipment," Redstone Arsenal, Huntsville, Ala., 1956.
3. R. Lusser—"A Study of Methods for Achieving Reliability of Guided Missiles," Technical Report No. 75, Bureau of Aeronautics, Redstone Arsenal, Huntsville, Ala., 1950.
4. Wayne Moore—Unpublished work on reliability for gear assemblies.
5. S. Siegel—*Non Parametric Statistics for the Behavioral Sciences*, McGraw Hill, New York, 1956.
6. C. M. Ryerson—"RCA Reliability Program and Long Range Objectives," RCA Publication, March, 1956, p. 15.
7. J. C. Bear—"Elements of Reliability Prediction," ARINC Monograph No. 4, Aeronautical Radio Inc., Washington, D. C., 1956.
8. M. A. Acheson—"Tools for Reliability Engineering," Electron Tube Life and Reliability, Sylvania Electric Products, Inc., Kew Gardens, N. Y., 1957, Chapter VII.
9. J. P. Guilford—*Fundamental Statistics in Psychology and Education*, Second Edition, McGraw Hill, New York, 1950.
10. R. Lusser—"Electronics—The Key Problem of Reliability," Redstone Arsenal, Huntsville, Ala.
11. H. B. Brown—"The Role of Specifications in Predicting Equipment Performance," Paper presented at Second National Symposium on Reliability and Quality Control in Electronics, Washington, D. C., 1956.
12. M. A. Acheson and G. V. Herrold—"The AQL Myth," Sylvania Electric Products, Inc., Kew Gardens, N. Y.

*Determining amount of stock for the head  
in relation to the wire diameter tells  
whether a part can be produced by . . .*

## Cold Heading

A headability index is simply the ratio of length of wire required for the head to diameter of the wire. Here's a quick method for finding that ratio and also for calculating weights of parts.

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**A** RULE of thumb for cold-heading is: A single-blow header can upset a length equal to approximately  $2\frac{1}{2}$  wire diameters, and a double-blow header can upset approximately  $4\frac{1}{2}$  wire diameters. There are also multiple-blow headers such as triple-blow headers, bolt-makers, and progressive headers.

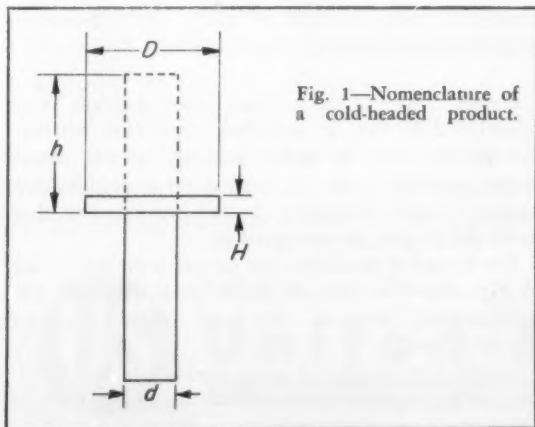


Fig. 1—Nomenclature of a cold-headed product.

Feasibility and economy of cold working, thus, depend upon how much wire is needed to form the head in relation to the wire diameter. This index is simply ratio  $h/d$ , Fig. 1.

For use with Table 1, the ratio is developed this way: Since volumes before and after heading are assumed to be equal,

$$d^2 h = D^2 H$$

or

$$h = \frac{D^2 H}{d^2}$$

And dividing both sides by  $d$  gives

$$\frac{h}{d} = \frac{D^2 H}{d^2 d}$$

An equivalent result is given by a convenient, alternate form:

$$\frac{h}{d} = \frac{W_D H}{W_d d} \quad (1)$$

where  $W_D$  and  $W_d$  are the weights of unit lengths of steel having diameters  $D$  and  $d$ , respectively. These weight factors are tabulated in Table 1. They



**Table 1—Weight of Unit Lengths of Steel Wire**  
(Weight in 0.001 lb.)

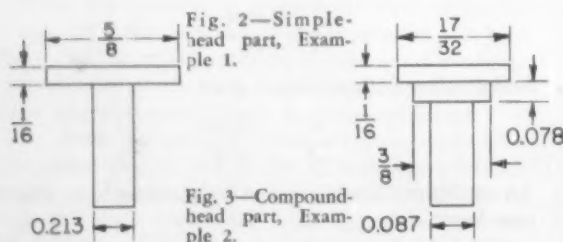
Diam	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800
0.000	2.23	8.90	20.03	35.61	55.84	80.13	109.06	142.45	
0.001	2.27	8.99	20.17	35.79	55.87	80.39	109.38	142.81	
0.002	2.32	9.08	20.30	35.97	56.09	80.66	109.89	143.17	
0.003	2.36	9.17	20.43	36.15	56.31	80.93	110.09	143.52	
0.004	2.41	9.26	20.57	36.33	56.53	81.20	110.31	143.85	
0.005	2.45	9.35	20.71	36.51	56.76	81.47	110.63	144.24	
0.006	2.50	9.45	20.84	36.68	56.99	81.74	110.94	144.60	
0.007	2.55	9.54	20.98	36.87	57.21	82.01	111.26	144.95	
0.008	2.60	9.63	21.12	37.05	57.44	82.28	111.57	145.31	
0.009	2.64	9.72	21.26	37.23	57.67	82.55	111.89	145.67	
0.010	2.69	9.82	21.39	37.41	57.89	82.82	112.20	146.03	
0.011	2.74	9.91	21.53	37.60	58.12	83.09	112.52	146.40	
0.012	2.79	10.00	21.67	37.78	58.35	83.36	112.84	146.76	
0.013	2.84	10.10	21.81	37.96	58.58	83.64	113.15	147.12	
0.014	2.89	10.19	21.95	38.15	58.80	83.91	113.47	147.48	
0.015	2.94	10.29	22.09	38.33	59.03	84.18	113.79	147.84	
0.016	2.99	10.38	22.23	38.52	59.26	84.46	114.11	148.21	
0.017	3.05	10.48	22.37	38.70	59.49	84.73	114.43	148.57	
0.018	3.10	10.58	22.51	38.89	59.72	85.01	114.75	148.93	
0.019	3.15	10.68	22.65	39.08	59.95	85.29	115.07	149.30	
0.020	3.20	10.77	22.79	39.26	60.19	85.56	115.39	149.66	
0.021	3.26	10.87	22.93	39.45	60.41	85.84	115.71	150.03	
0.022	3.31	10.97	23.08	39.64	60.65	86.11	116.03	150.39	
0.023	3.37	11.07	23.22	39.83	60.88	86.39	116.35	150.76	
0.024	3.42	11.17	23.37	40.01	61.12	86.67	116.67	151.13	
0.025	3.48	11.27	23.51	40.20	61.35	86.94	116.99	151.49	
0.026	3.53	11.37	23.65	40.39	61.58	87.22	117.32	151.86	
0.027	3.59	11.47	23.80	40.58	61.82	87.50	117.64	152.23	
0.028	3.65	11.57	23.95	40.77	62.05	87.78	117.96	152.60	
0.029	3.70	11.67	24.09	40.96	62.29	88.06	118.29	152.97	
0.030	3.76	11.77	24.24	41.16	62.52	88.34	118.61	153.34	
0.031	3.82	11.88	24.39	41.35	62.76	88.62	118.94	153.70	
0.032	3.88	11.98	24.53	41.54	62.99	88.90	119.26	154.08	
0.033	3.94	12.08	24.68	41.73	63.23	89.19	119.59	154.44	
0.034	4.00	12.19	24.84	41.92	63.47	89.47	119.92	154.82	
0.035	4.06	12.29	24.98	42.12	63.71	89.75	120.24	155.19	
0.036	0.288	4.12	12.40	25.13	63.95	90.03	120.56	155.56	
0.037	0.305	4.18	12.50	25.28	64.18	90.32	120.90	155.93	
0.038	0.321	4.24	12.61	25.43	64.42	90.60	121.23	156.31	
0.039	0.338	4.30	12.71	25.58	64.66	90.88	121.56	156.68	
0.040	0.356	4.36	12.82	25.73	64.90	91.17	121.88	157.05	
0.041	0.374	4.43	12.93	25.88	65.15	91.45	122.21	157.42	
0.042	0.393	4.49	13.04	26.03	65.40	91.74	122.54	157.79	
0.043	0.411	4.55	13.14	26.19	65.65	92.03	122.87	158.16	
0.044	0.431	4.62	13.25	26.34	65.90	92.31	123.21	158.53	
0.045	0.451	4.68	13.36	26.49	66.11	92.60	123.54	158.90	
0.046	0.471	4.74	13.47	26.65	66.35	92.88	123.87	159.27	
0.047	0.491	4.81	13.58	26.80	66.60	93.17	124.20	159.64	
0.048	0.513	4.88	13.69	26.96	66.87	93.46	124.53	160.00	
0.049	0.534	4.94	13.80	27.11	67.08	93.75	124.87	160.44	

are used in connection with Equation 1 to find  $h/d$ . Also, they may be multiplied by lengths to give weights of cylindrical parts or stock.

**Example 1:** Find the length of wire required to make the head illustrated in Fig. 2. Substitutions in Equation 1 yield:

$$\frac{h}{d} = \frac{(86.94)(0.062)}{(10.10)(0.213)} = 2.5$$

where 86.94 and 10.10 are values obtained from Table 1 for diameters 0.625 and 0.213, respectively.



Therefore, a head of  $\frac{5}{8}$  by  $\frac{1}{16}$  in., made of 0.213-in. diameter wire, would take 2.5 diameters or 0.532-in. length of the wire. According to the rule of thumb, this head can be produced by a single-blow header.

**Example 2:** On a pan-head and shoulder product, Fig. 3, calculate the head and shoulder separately, and add the resultant head diameters:

For the 17/32-in. head,

$$\frac{h}{d} = \frac{(62.76)(0.062)}{(0.187)(7.78)} = 2.67$$

For the  $\frac{3}{8}$ -in. shoulder,

$$\frac{h}{d} = \frac{(31.30)(0.078)}{(0.187)(7.78)} = 1.68$$

Therefore, there are  $2.67 + 1.68 = 4.35$  diameters of 0.187 wire or 0.813 in. length of wire.

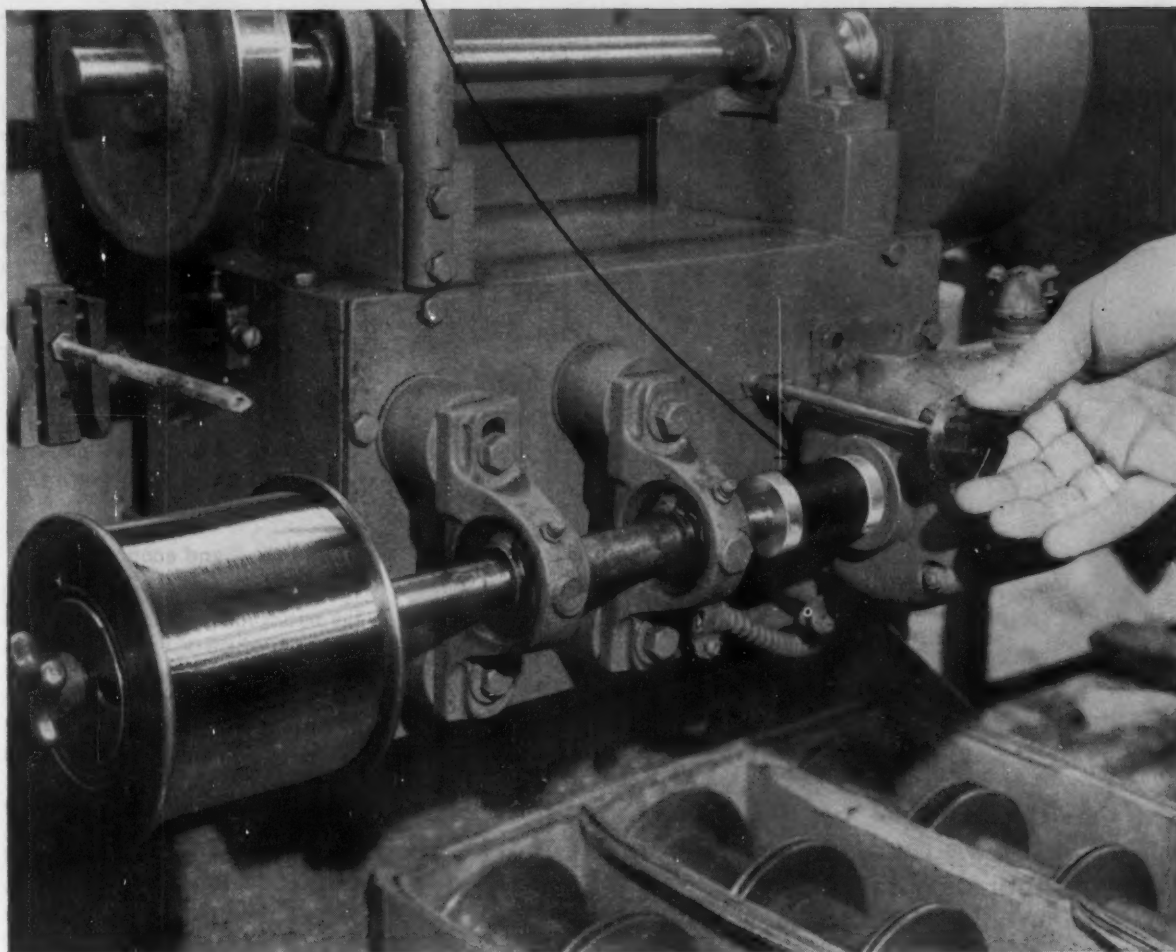
**Design Tips:** If the product head requires more material than can be provided, determine whether the product can be made smaller, or the shank larger, so that it can be headed on a double-blow header. Larger diameters can be headed, but they make the product more expensive.

For threaded products, the proper wire size to use in Equation 1 is the minimum pitch diameter. On nonthreaded products, the basic shank diameter should be used.

Large, thin heads are to be avoided in cold-heading design because they require excessive flow of material.



## FLEXIBLE COUPLINGS



### Compensating for misalignment in Viking Wire Co., Inc.

Wire drawing subjects machines to considerable shock loads. The Viking Wire Co., Inc. has a battery of 26 machines in the drawing room. This is one of the newest plants in the industry and has the latest in machinery, equipment and methods.

"U.S." Flexible Couplings were selected for all the machines (see picture) principally to absorb shock loads and compensate for misalignment. Other reasons for selection were ease of installation,

lack of maintenance or lubrication and just plain overall efficiency.

These couplings are so simple in design that the cost is very low compared with other couplings. Insist on having these tried on your machinery—and then watch your costs go down.

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**Reading the rocks at rocket rate**  
One outstanding example of Ozalid

200 SS paper's super-speed usefulness is in the field of geology ... where, in the exploration for oil and gas, it has had an enthusiastic reception.

Today, internationally known companies like the Schlumberger Oil Well Survey Company are employed to read every rock formation, every stratum of sand or substance beneath the surface that tells them first *where* to drill, and later, in the drilling operation, *when* to stop. In these operations, recording machines based on the Oscillograph principle record sound and light waves on photographic paper or film. Geologists can then read and interpret these records, known as "well-logs," with a good measure of accuracy.

Since drilling operations run as high as \$40,000 per day, speed of communication is understandably

important. That's where Ozalid 200 SS comes in. As the "well-logs" are taken from the recording devices, they are immediately processed and dried in field trucks. Duplicates are made in seconds right on the trucks on Ozalid 200 SS using Bambinos and/or Ozamatics®, and then sped to geologists for interpretation. Copies are simultaneously dispatched to drilling contractors and well owners. Thus 200 SS shortens the critical ... and expensive ... time interval between the recording of well pressures and the geologists' "make or break" decisions.

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Naturally you'd expect that with all the outstanding benefits Ozalid 200 SS can give you, the cost would be a little higher. Not the case at all. It actually costs no more—and you save in *many* other ways as well. We'd like to quote from a truly unsolicited testimonial letter received from Mr. R. C. Purvayn, Purchasing Agent for Packaging Corporation of America: "We have found this paper to be of a nature that we can take letters, customer orders, etc., and run them on our Ozalid machine without the use of any type of masters. We have recently discontinued in a large measure the use of our (COMPETITIVE NAME DELETED) paper which costs us in the neighborhood of four and one-half cents per copy. Another added benefit with your 200 SS paper is that in filing we incur no wrinkling problem which has been a troublesome factor ... we appreciate the savings which we have made with the use of your 200 SS paper ..."

To sum it all up, Ozalid's Blue Line formula 200 SS paper facilitates higher printing speeds plus better image density for easiest reading ... means time and money savings for you. If you'd like a convincing demonstration, may we suggest that you contact your Ozalid representative? He'll be happy to oblige ... without obligation.

**Ozalid, Johnson City, New York. A Division of General Aniline & Film Corp.**

# Energy Conversion Processes

A progress report on developments in three methods:

- Thermoelectric
- Thermionic
- Photovoltaic

**GEOFFREY W. WILSON**

Westinghouse Research Laboratories  
Pittsburgh, Pa.

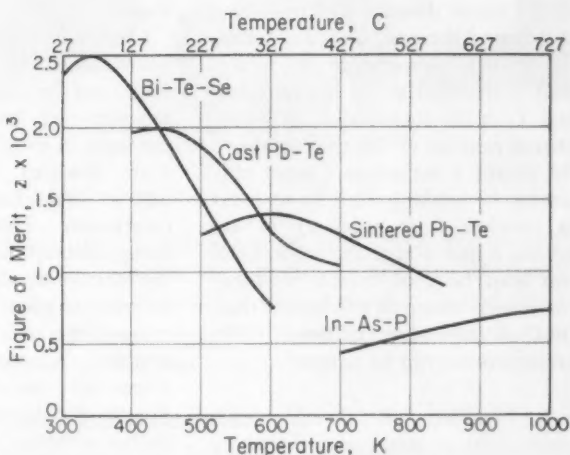


Fig. 1—Values of figure of merit for typical n-type thermocouple materials.

**C**ONVERSION of heat or light directly into electrical power without the use of rotating machinery is currently a subject of very intensive study. Three promising techniques utilize thermoelectric, thermionic, and photovoltaic phenomena. None of the three need moving parts, so operation can be silent and free of gyroscopic effects. Unlimited shelf life is claimed. Based on materials which have become available over the past few years, an efficiency of 10 per cent was theoretically obtainable in 1958. Currently, this figure has been increased to 17 per cent, and values of 25 to 30 per cent are anticipated during the next five years.

**Thermoelectric Conversion:** Rapid strides made in the last few years with converters based on the thermoelectric effect have been due to the use of semiconducting compounds rather than metallic alloys as materials for the components of thermocouples. One of the most important requirements of thermocouples material is that it should have as high a figure of merit,  $z$ , over as wide a range of temperature as possible. Figure of merit is inversely proportional to electrical resistivity and thermal conductivity.

Other requirements of good thermocouple materials are:

1. High charge carrier mobility.
2. High effective mass.

3. Low lattice thermal conductivity.
4. Optimum charge carrier concentration.

In addition, operation at high temperatures is required for efficient thermoelectric conversion. In this respect, four major limitations on the use of materials at high temperatures are:

1. Chemical stability and melting.
2. Insufficient solubility of the doping material to give the correct or optimum carrier concentration.
3. Production of intrinsic charge carriers.
4. Anomalous electronic thermal conductivity.

Typical figures of merit are shown



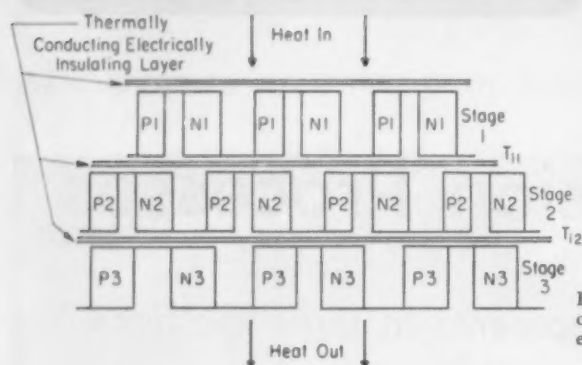


Fig. 2—Arrangement of cascaded thermoelectric generator.

in Fig. 1 for several n-type materials. To make a generator of 20 per cent efficiency, materials must have a figure of merit greater than  $2 \times 10^{-3}$ , and be capable of use above 800 C.

From the general formula for the efficiency of a thermoelectric converter, it is evident that Carnot efficiency varies directly with the temperature difference,  $T_h - T_c$ , where  $T_h$  is the temperature at which heat is absorbed at the hot junction, and  $T_c$  is the temperature at which heat is rejected at the cold junction. To obtain a maximum Carnot efficiency, by making  $T_h - T_c$  as great as possible, it is necessary to use several p and n-type materials. Each can then be used over a temperature range where its  $z$  is higher than that of any other material. Two arrangements can be adopted:

1. Numbers of thermocouples electrically in series and thermally in parallel can be staged in thermal series, Fig. 2. In such a staged or cascaded generator, each stage must be electrically insulated from its neighbors, but good thermal contact must be preserved between stages. The geometry of the stages

must be adjusted to maintain the preselected interface temperatures.

It has been shown that maximum efficiency is found when the number of stages is infinite. Practical considerations, of course, limit the number of stages; however, the upper limit of efficiency can be approached by using even a small number of stages.

Output from such a generator can be obtained in two ways. Each stage can be connected to its own separate load. In this case, however, the leads in which there is a temperature gradient have power losses due to Joule heating and thermal conduction. These losses can very easily amount to the equivalent of the output of one or more thermocouples per stage and can drastically reduce the efficiency of the assembly. Alternatively, individual stages may be connected in series, Fig. 3. In this case, an additional design criterion is imposed by the necessity to equalize the current outputs from all stages.

2. The other manner in which several materials may be utilized in a generator is by making the individual legs of each thermocouple

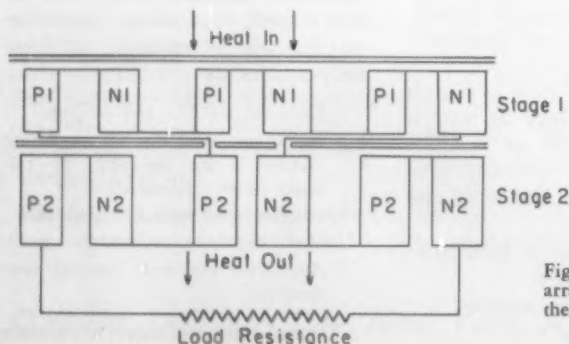


Fig. 3—Series-connected arrangement of staged thermoelectric generator.

from pellets of different composition connected electrically and thermally in series. Such an arrangement, termed a segmented generator, is theoretically always lower in efficiency than a staged device. In fact it is found that the addition of further segments may actually lead to a decrease in overall efficiency.

**Thermionic Conversion:** A very small amount of electrical energy can be obtained from a rectifying tube by simply heating the cathode and connecting the anode to the cathode through a meter. Electrical power obtained is minute because of the space charge barrier, Fig. 4. To obtain useful amounts of electrical power out of such a device it is necessary to eliminate the space charge barrier. Four methods have been suggested:

1. Bring anode and cathode very close together so that the space between them is less than 0.0005 in.
2. Introduce positive ions to neutralize the excess electrons forming the space charge.
3. Use crossed electric and magnetic fields to guide the electrons from cathode to anode.
4. Use a grid or third electrode to accelerate the electrons away from the cathode.

One of the major problem areas is the development of a suitable cathode material. Large electron emissions are required at relatively low temperatures. At the moment, such surfaces are impossible to obtain because of the requirement that they should have long life at operating temperature.

**Photovoltaic Converters:** Energy converters which use the photovoltaic effect do not act as heat engines but use incident electromagnetic radiation directly. They do not suffer from the limitation on efficiency imposed by the Carnot cycle. In principle, the incident radiation produces ionization in a p-n junction between two semiconductors. The products of such ionization—holes and electrons—diffuse in opposite directions, Fig. 5, producing a voltage and current across the junction. This may be picked off by suitably placed electrodes and made to do useful work in an external load. The number of hole-electron pairs produced depends upon the energy gap of the

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premium. Elimination of couplings, bases and adapters results in significant savings. Reduced weight means lower shipping costs . . . and their compactness simplifies assembly operations and lowers production costs.

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These close-coupled pump and motor units are but a small part of Tuthill's complete line of over 800 different standard models. In addition, Tuthill's experienced staff of application engineers will work with you in designing a special unit to precisely meet all the requirements of your particular application . . . "fit the pump to the problem."

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*Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 GPM; for pressures to 1500 PSI; speeds to 3600 RPM.*



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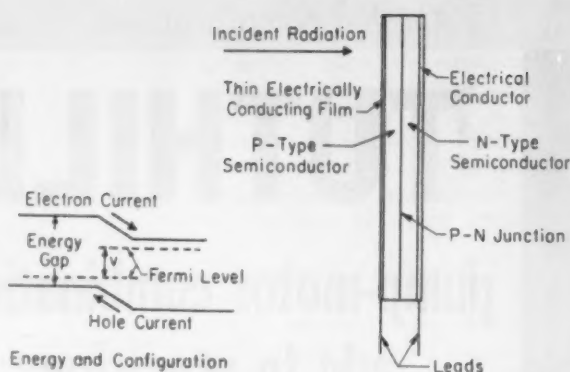
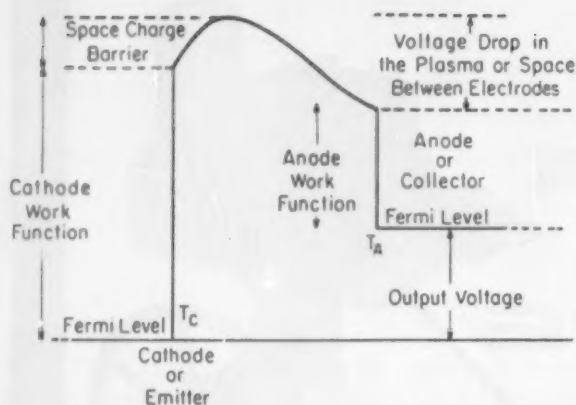


Fig. 5—Functional members of a photovoltaic converter.

Fig. 4—Energy diagram of a thermionic converter.

semiconductor materials in the p-n junction, and upon the energy content of the incident radiation.

Factors which lower the efficiency of conversion obtainable from a photovoltaic device are:

1. Some of the incident radiation is reflected from the surface of the cell.
2. Some of the incident radiation has a frequency outside the spectral response of the cell.
3. Some of the electron-hole pairs recombine before they have diffused to the junction.
4. Some electron-hole pairs which are initially separated diffuse back across the junction, constituting an unwanted reverse current.

**Practical Devices:** Present objective is to produce a generator with an efficiency of 20 per cent in the next 12 to 18 months. A proposed 500-watt generator will employ forced air cooling and give 14.3 watts per lb. A 5-kw unit using water cooling is now being built and should give 8 watts per lb. One of the main difficulties is the elimination of internal thermal and electrical contact resistances in the thermocouples. Another problem, in certain types of generators, is the stack losses associated with the heat exchanger on the hot side of the generator.

In thermionic converters, major increases in efficiency must wait for a cathode material in which electron emission is sufficiently large at high temperatures.

The efficiency of silicon solar cells is approximately 80 per cent at present. The use of materials other

than silicon is being explored, and it is reported that gallium-arsenic and cadmium-sulphur units work at efficiencies of 6.5 and 9 per cent respectively.

AIEE paper, "A Review of Thermo-electric, Thermionic, and Photovoltaic Energy Conversion," presented at the 1960 conference on Electrical Engineering in Space Technology, Dallas, Texas, April, 1960.

## A Patent Refresher

ROBERT H. HENDERSON, patent attorney, Western Union Telegraph Co.

HERE are a few of the more important rules and practices that apply to inventing:

1. Date and sign everything you write, and write everything you learn concerning an invention, preferably in a chronological record. Very often, occurrences which are seemingly trivial carry great weight at a later time. In any event, a record which is full, clear, and comprehensive is much more likely to be believed.

When others act for you in any capacity during the inventive period, if they may not be keeping the kind of records that you should keep, then your record of their activities should be as complete as if you had done it all yourself.

It is commonplace for a desperate inventor to attempt to show that he procured supplies of special goods for making the invention on a given date, and it is equally common for him to be unable to prove that they were actually intended for use in that particular invention, because he had never written it down!

2. Date and sign each sketch

given to the draftsman. Make sure that the sketch is self-explanatory and that it is preserved. Years may elapse before it is needed, but this record and the all-important first date on it are outstandingly good evidence, and they usually antedate the formal drawings by a substantial period, which is vital surprisingly often. See that the draftsman's initials and the correct date are put on the sketch as soon as he receives it. He will provide the indispensable corroboration, and his initials and the date, noted at the time, will provide credibility to his testimony.

3. Likewise, corroborate the notebook data at regular intervals by inviting a competent person to read, understand, date, and sign it at the foot of the notes.

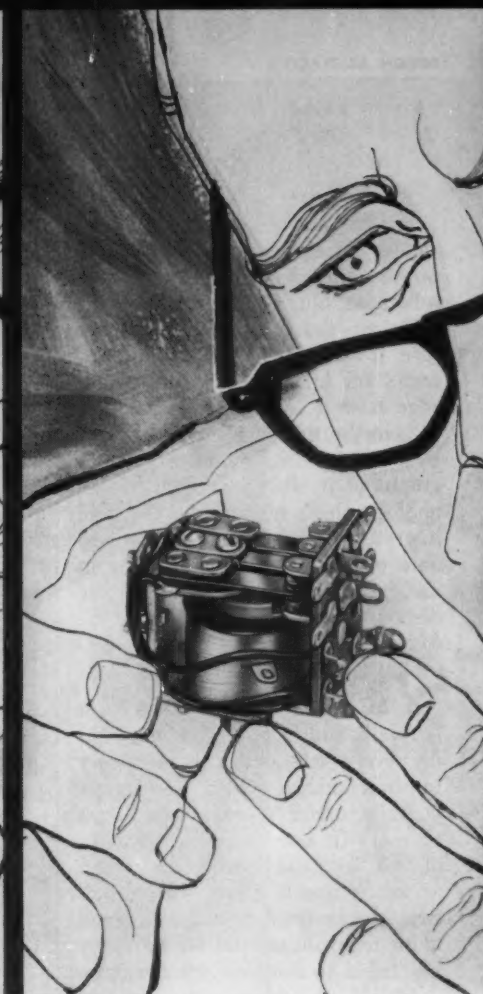
4. It is of the greatest importance that the record show persistent diligence in somehow advancing every idea which may later ripen into a patent, even though many such ideas are carried forward simultaneously.

Order supplies, make some test, adjustment, computation, rerun, substitution, or otherwise forward each promising idea (and all the unpromising ones which you do not

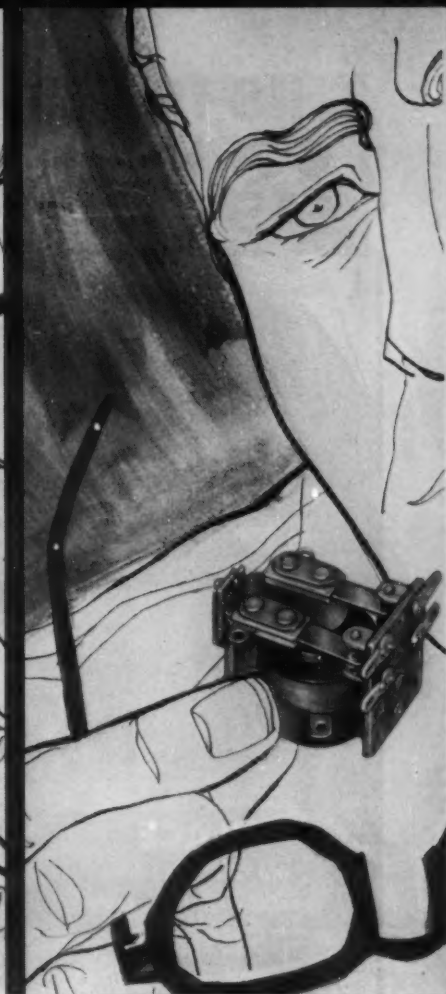




KCP SERIES



KT SERIES



KR SERIES

## three for dependability at low cost

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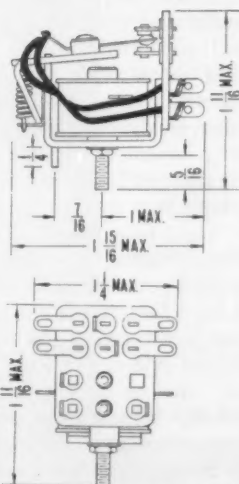
Here are only three of a large family of "K Series" relays by P&B. Blood brothers all, they are distinguished by fine craftsmanship and design maturity. Together they will handle a multitude of switching requirements.

Many design engineers find it saves time, saves money to integrate their circuits with related P&B relays. Makes sense, doesn't it?

**KR**—A small, lightweight relay used widely in communications and automation. Engineered for long life and dependability. 3PDT max. AC or DC. (See engineering data.)

**KT**—Designed for antenna switching. Capacitance: 0.5 mmfds between contacts. Terminal board is glass melamine and stack insulation is glass silicone for minimum RF losses to switch 300 ohm antenna line. 3 PDT max. AC or DC.

**KC**—Low cost plate circuit relay with sensitivity of 125 mw per pole. Factory adjusted to pull-in on specific current values. Available open, hermetically sealed or in clear plastic dust cover with standard octal-type plug. 3 PDT max. DC.



#### KR ENGINEERING DATA

**GENERAL:**  
Breakdown Voltage: 500 volts rms minimum between all elements.

**Temperature Range:**  
DC Coils—45°C to 85°C.  
AC Coils—45°C to 70°C.

**Terminals:**  
Pierced solder lugs standard. Octal 8 and 11 pin plug-in headers available.

**Enclosures:** Type K—Hermetically sealed.  
Type P clear cellulose acetate dust cover.

**CONTACTS:**  
**Arrangements:** 3 Form C (3PDT) max.  
**Material:** 1/8" dia. fine silver (gold plated).  
Other materials available to increase contact capacity.  
**Load:** 5 amperes 115V 60 cycle resistive.

**COILS:**  
**Resistance:** 16,500 ohms max. AC or DC.  
**Power:** 1.1 watts minimum to 4 watts maximum for DC at 25°C ambient.

**Duty:** Continuous.  
**Insulation:** Centrally impregnated with insulating varnish.

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### DESIGN ABSTRACTS

wish to abandon) at frequent intervals. Once a week would not be too often.

5. The model is the most convincing evidence of invention that can be offered when properly corroborated, but it usually will be insufficient unless someone else has seen it operate, knows how it operates and knows of his own knowledge how it is constructed.

Save the model, if possible, or at least a revealing series of photographs of it, duly identified by the photographer's number thereon, and his records, or by his signature and date on the back, and fastened in the notebook together with the demonstration witnesses' acknowledgments.

6. In testing a model to see if it is finally satisfactory, you must apply every test which is necessary to show that it would work satisfactorily under practical conditions of use. In one case, the inventor of an airplane carburetor failed to test it upside down. In another case, the inventor of a deicer tested it for temperature and for humidity but failed to combine the two. Accordingly, you should not tarry after the invention is completed and properly tested.

While an invention which has been diligently developed is "actually reduced to practice," and a retroactive date of invention thereby determined for it when it is first properly and completely tested, adjusted and used, further delay to extend the tests or the use before filing will surely place upon you the burden of showing that any intervening inventor was not the first. Long delayed filing may enable him to show that you have abandoned your right to a patent. This intervening inventor who thought of the idea after you did, but worked faster and filed first, is not entitled to the patent if you can produce good and sufficient evidence of what you have done. But he does have a tactical advantage because he is not required to have done any testing at all. He may therefore put you to your proof without submitting any evidence himself, by relying on his filing date alone.

7. If a practical test in actual

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The use of investment casting meant five times greater production without highly-skilled labor, a one-per-thousand reject rate, and a per unit cost of a third that of machined parts.

This wide freedom of choice in alloy, as well as flexibility in design may help you with your parts manufacturing problems. Try "the Hitchiner way" yourself and send us a sample or blueprint for our "engineered quotation" — no obligation.



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Coast to Coast Engineering Representatives

commercial use seems to be the answer, remember that the inventor must swear in the terms of the statute that the invention was "not in public use or on sale in this country for more than one year prior to his application." A year of public use runs very fast to raise this statutory bar. If this kind of testing is imperative, and more than a year is needed, the bar must be avoided by creating an experimental use. This is done by making sure that the provable facts show a primary purpose of testing and perfecting, rather than of profit. Frequent or regular tests, inspections, adjustments and changes help to show this purpose, and even avoidance of profits is sometimes undertaken to make this purpose clearly appear. Of course, any sale or offer of sale of the invention during this phase should be avoided and even the sale of its produce is better avoided, if the strongest case for patentability is needed.

8. Beware of publication. Again remember that a statutory bar appears one year from the date of unrestricted publication of the invention, but here mere publication is an instant bar to patents in some foreign countries.

9. Use your technical skill to visualize the entire breadth of your invention. Your patent will describe very closely the one method of practicing your invention which you now feel is best and most important, but it is commonplace for a patent to have its value based on some secondary aspect which seemed relatively minor when written. Less than a tenth of Morse's telegraph patent is devoted to describing the relay system on which long-distance telegraphy was based. The remainder of this pioneer patent was unsuccessful.

10. Be sure that what you write about the mode and manner of operation of the invention is correct. You are not required to know the ultimate details of theory on which it operates, and a mistaken explanation of this can be far worse than none at all.

Article, "A Patent Refresher," Western Union Technical Review, Vol. 14, No. 3,



# 15

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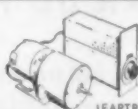
\*Lear patented magnetic-particle mixtures are totally dry—which means no leaking, no packing; have more proportional shear strength; provide a faster, more predictable response; and protect clutch surfaces from wear during slipping conditions. Lear has more, application-proven clutches—designed for high-response servo systems and other intermittent load operations—than any other manufacturer. Ask about the one best suited to your needs.



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Circle 500 on Page 19

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### DESIGN ABSTRACTS

July, 1960, pp. 119 to 123.

## hydraulic

### Clearance in Viscous Dampers To Limit High Frequency Force

M. E. Gurtin, General Engineering Laboratory, General Electric Co.

Steady-state vibration of a single degree of freedom system with clearance in the viscous damper. Viscous damping is effective in limiting the resonant force transmission of a single - degree - of - freedom system. However, the force transmitted to the foundation at frequencies much higher than the resonant frequency increases with increasing damping.

A method which may be used to overcome this difficulty is the intentional use of clearance in the viscous damper. When the amplitude is high, which is the case at resonance, the damper acts to dissipate energy. However, when the amplitude is low, as is true at frequencies much higher than the resonant frequency, the damper is inactive and the force transmitted to the foundation is low. This paper determines the parameters involved in designing a system such as this.

ASME Paper No. 60-SA-17, "On the Use of Clearance in Viscous Dampers to Limit High Frequency Force Transmission," presented at the Summer-Annual Meeting, Dallas, Texas, June, 1960, 3 pp.

### Friction Effects of Transmission Fluids and Clutch Plate Materials

John J. Rodgers, and Merrill L. Haviland, Fuels and Lubricants Dept., General Motors Research Laboratories.

The effect of variables on the shift performance of an automatic transmission, particularly in the shift from second to third. The 2-3 shift can be made less objectionable by using transmission fluid in which no increase in coefficient of friction occurs with decreasing sliding speed. Of six additives studied, only one—dilaurylphosphate—appreciably improves transmission operation. The same compound improves the friction characteristics of a base stock. Sulfurized sperm oil and oleic acid, referred to as "oiliness additives,"



are not effective in imparting satisfactory friction characteristics or satisfactory transmission operation.

No significant differences are reported in shift performance or friction characteristics of paper materials in the presence of a desirable fluid. With an undesirable fluid, however, results indicate that some improvements can be made through selective use of friction materials. In addition, these studies indicate that additives attach themselves to paper surfaces as well as steel surfaces.

Friction characteristics with cork on steel were found to be similar to those with paper on steel. However, the coefficient of friction values are significantly higher than those with paper on steel. With steel on steel the coefficient of friction values were significantly lower than those with paper on steel. Further, the friction characteristics are undesirable, irrespective of the two fluids employed in the study.

Oxygen has often been thought to be detrimental to transmission fluids because oxidation products are formed which can hamper transmission operation. However, in transmission tests using an inert atmosphere, it was found that oxygen must be present before satisfactory transmission performance can be obtained, even with fluids normally considered to be satisfactory.

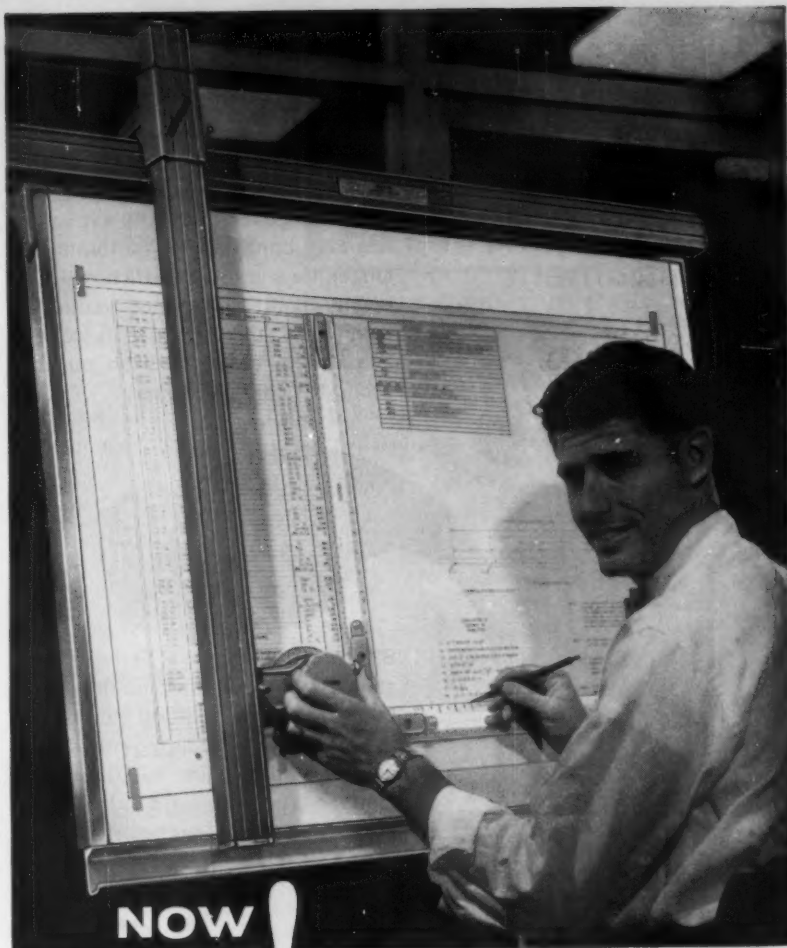
SAE Paper No. 194A, "Friction of Transmission Clutch Materials as Affected by Fluids, Additives, and Oxidation," presented at the SAE Summer Meeting, Chicago, June, 1960, 13 pp.

### Stresses in Thin-Walled Pressure Vessels With Ellipsoidal Heads

H. Kraus, engineer, G. G. Bilodeau, senior mathematician, and B. F. Langer, consulting engineer, Westinghouse Electric Corp.

Calculations made with a digital computer for a useful range of shell parameters. Results are in the form of stress indexes and stress intensity indexes, the latter based on the maximum shear theory of failure.

It is found that the ASME Boiler and Pressure Vessel code gives satisfactory designs for ellipsoidal pressure vessels with  $\beta \leq 2$ , where  $\beta$  is the ratio of the major axis to the



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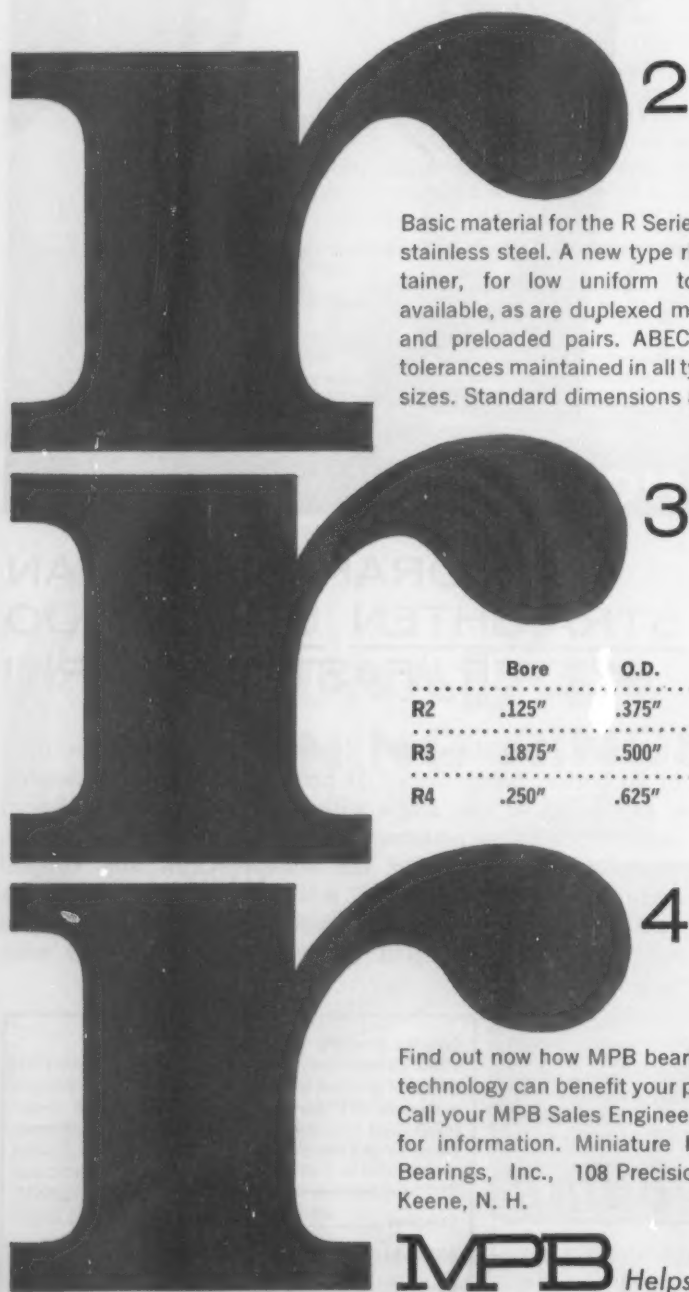
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## DESIGN ABSTRACTS

minor axis of the ellipsoidal head. For heads with  $\beta > 2$ , some improvements are required.

It is recommended that for vessels with  $D/t \leq 100$ , the  $K$  factor in the ASME code formula for ellipsoidal heads be redefined as follows:  $K = D_i/4h$ .

ASME Paper No. 60-SA-12, "Stresses in Thin-Walled Pressure Vessels with Ellipsoidal Heads," presented at the Summer Annual Meeting, Dallas, Texas, June, 1960, 12 pp.

### High-Performance Jet Pump Using Boundary Layer Control

William Graham Wells, Research assistant, Aerophysics Dept., Mississippi State University

Application of boundary-layer technology to a subsonic jet pump. A peak efficiency of 41 per cent is attained as compared to conventional jet pumps which have less than 10 per cent. The high-performance jet pump studied incorporates features to exploit mixing improvement which occurs in a favorable pressure gradient, and to overcome the adverse condition encountered during diffusion. In addition, a theoretical expression which is derived for ideal efficiency of mixing in a favorable pressure gradient shows agreement with experimental results.

ASME Paper No. 60-AV-15, "Theoretical and Experimental Investigation of a High Performance Jet Pump Utilizing Boundary Layer Control," presented at the Aviation Conference, Dallas, Texas, June, 1960, 8 pp.

## techniques

### New Plug-In Component for Computation and Data Reduction

L. D. Kovach and W. Comley, Douglas Aircraft Co.

Application of the Quadratron to solution of nonlinear expressions. Unique electrical and mathematical techniques employed make possible the generation of such functions as the square, square root, product, quotient, sine, cosine, and tangent. The Quadratron is a passive, solid-state, analog component which can be used in a variety of ways. Its unique characteristic depends on the nonlinear properties of the silicon carbide varistor. Commercial varis-

tors having an exponent of approximately 2.4 are corrected so that the exponent is 2. The correction is such that the error of the Quadratron does not exceed 0.4 per cent based on a full scale of 100 v.

In computation and simulation, a multiplier can be assembled easily from three amplifiers and two Quadratrons. A sine-cosine resolver can be assembled using amplifiers and Quadratrons in accordance with particular circuits. The range of angles that can be resolved is between  $-180$  and  $+180$  F. In simulation work, a phase-sensitive or controlled-carrier modulator is often required. Many phase-sensitive modulators currently in use base their operation on the switching properties of diodes. This principle also generates unwanted high-frequency terms. Because the Quadratron modulator is a true multiplier, no undesirable high-order terms are generated. In data reduction, the Quadratron simplifies problems of least squares, ratio compression, linearization, and transmissibility.

ISA Paper No. 31-SF60, "Applications of the Quadratron to Computation and Data Reduction," presented at the Summer Instrument-Automation Conference, San Francisco, May, 1960, 19 pp.

## processes

### Nitriding for Increased Wear and Fatigue Resistance

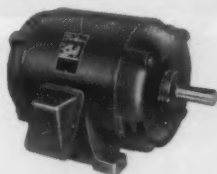
John H. Shoemaker, president, Kolene Corp. and George Bidigare, director, Research & Development, Commercial Steel Treating Corp.

Liquid nitriding process applied to low carbon, alloy, stainless, tool steels, and heat resistant steels; also gray, alloy, nodular or ductile, malleable, and pearlitic irons. The process obtains the desired results in a short period of time, without large equipment investment, without high manufacturing costs, and with no brittle white layer.

When low carbon steel is immersed in this specially formulated molten salt bath operating at  $1050$  F, decomposition of the salt in contact with the steel liberates specific amounts of carbon and nitrogen. Both carbon and nitrogen, when subjected to the same conditions of diffusion in ferrite, have vastly

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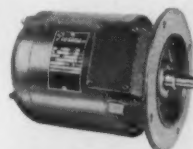
#### TEPC and EXPLOSION-PROOF

External fan draws cool air across motor toward driven machine.

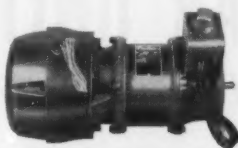


#### DIRECT CURRENT

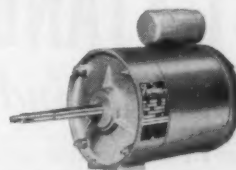
High starting torque, good overload capacity and high electrical efficiency. For rough usage.



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Special speed-increasing unit, 660 HP, input speed range: 1,500 to 3,000 RPM, output speed range: 20,000 to 40,000 RPM.



Special right-angle speed-increasing unit, 600 HP, 2,500/19,932 RPM, with double helical and spiral bevel gears.



Special 375 HP speed-increasing unit, with two speed ranges: 6,000/10,769 RPM and 6,000/15,100 RPM.

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FB-1196

### DESIGN ABSTRACTS

different solubility rates. Carbon is ten times less soluble in ferrite than nitrogen, and, therefore, very quickly forms iron carbide particles at the surface of the part. The iron carbides act as nuclei so that the nitrogen will precipitate at the surface to form the nonbrittle and desirable iron nitrides  $\text{Fe}_3\text{N}$  and  $\text{Fe}_4\text{N}$ . This outer surface is known as the compound layer.

The nitrided surface of plain carbon steel is not brittle, but is tough and wear-resistant, and has good anti-galling and anti-seizing properties even when run without lubrication. Distortion and growth after nitriding of finished machined and ground parts is negligible, providing the parts are free of residual stresses prior to treating.

SAE Paper No. 178B, presented at the SAE Summer Meeting, Chicago, June, 1960, 13 pp.

## electrical

### Performance of Electrical Connectors at High Altitude

Arlie L. Coats, Bendix Aviation Corp.

Observations and significance of a critical altitude at which electrical connectors fail. In the altitude range of 100,000 to 200,000 ft, a critical pressure is reached at which the air gaps between wire terminations in electrical connectors exhibit their poorest electrical breakdown characteristics. Electrical circuits that must operate in this range in unpressurized areas can be expected to break down at voltages less than 300 v peak unless special provisions are made. As a normal safety factor, it would be well to limit operating voltage on unprotected connectors in these areas to approximately 150 v peak. Other malfunctions, caused by conditions at high altitude, include sparkover and corona.

The obvious solution to the problem of improving performance in this region is to imbue the terminals in potting compound or in resilient grommets to provide continuous insulation. If it is assumed that this approach will reliably prevent actual sparkover, the voltage rating of the connectors still cannot be increased, in many cases, due to the fact that corona will continue to be a severe



problem. A technique for successfully handling this condition calls for a harness assembly with a gastight outer sheath sealed to all connectors. The shields are carried inside this gastight sheath and so terminated at the connector shells that no particular stress points exist.

AIEE Paper No. 60-984, "Performance of Electrical Connectors at High Altitude," presented at the AIEE Pacific General Meeting, San Diego, Calif., August, 1960, 4 pp.

## mechanical

### Gear Design For Noise Reduction

William D. Route, Chevrolet Engineering Center

Widely accepted design rules, believed to aid in the control of gear noise, are:

1. Obtain total contact ratio greater than 2.5, with a least involute contact ratio not less than 1.2.
2. Select the finest pitch and lowest pressure angle consistent with the strength requirements.
3. Avoid tooth action close to the base circle.
4. Favor a long angle of recess and short approach.
5. Select an even number of pinions and space to have half of them engage half way in the interval of engagement.
6. Provide backlash, dimensional control of mounting, or floating elements to avoid tight mesh.
7. Modify lead and involute to compensate for tooth deflections and dimensional errors.

SAE Paper No. 208E, "Gear Design for Noise Reduction," presented at the SAE Summer Meeting, Chicago, Ill., June, 1960, 9 pp.

### Epicyclic Gear Trains

Bengt Jacobsson, professor, Head of the Institute of Machine Elements, Chalmers University of Technology (Sweden)

Torque distribution, power flow, and zero output conditions of epicyclic gear trains. Behavior of epicyclic gear trains is treated thoroughly by an arbitrarily chosen example. The basis for analysis is an efficiency which is obtained when the planet carrier is at rest. This efficiency is normally thought of as a constant value, in practice. Although further research might

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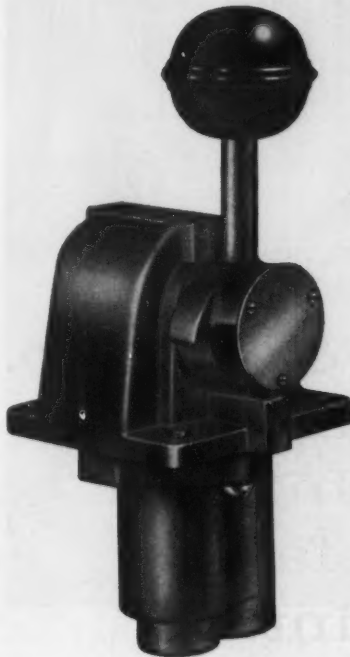
The famous "A" Pilotair Valves, the deluxe air directional valves, are now available at economy prices . . . thanks to new manufacturing processes and simplicity of design.

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Several different models are offered in both three-way and four-way operation. Prices range from as little as \$18.30 up to \$29.50. All operate efficiently at 250 psi maximum air pressure . . . and in a temperature range of from -40 degrees F. to +200 degrees F.



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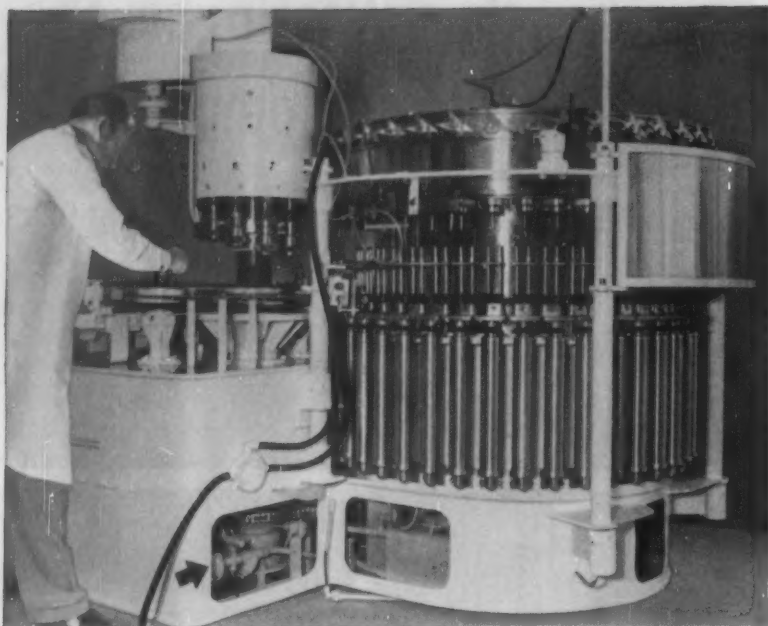
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## Crown Cork & Seal Co. put B&S Pumps in 50 new machines - never had a failure or a complaint!

The whole top of this new bottle-filling machine revolves on a thin film of oil that is maintained in a large hydrostatic bearing by a pump. The same oil acts as a seal for air, being distributed to bottle-lifting cylinders right through the bearing.



B&S No. 111 1/4 hp motor-driven gear pump (arrow) supplies oil at 35 psi to hydrostatic bearing.

It's easy to see that this manufacturer can't take chances on a pump failure; if the pressure drops, the whole machine shuts down. At customer production rates of up to 320 bottles a minute, it would be a very costly failure.

That's why Crown Cork & Seal Company uses Brown & Sharpe pumps. They are built to the high quality standards of machine tools.

Of the Brown & Sharpe pumps Crown has put in 50 new machines — not one has ever failed or caused a complaint.

For trouble-free pumps in your machines—contact Hydraulics Division, Brown & Sharpe Mfg. Co., Providence 1, R. I., or your nearest B&S engineer-representative.

**Brown & Sharpe**  
PRECISION CENTER

### DESIGN ABSTRACTS

show that efficiency is not exactly the same in both power flow directions, torque distribution will still be valid. Moreover, the value of efficiency may show slight variations with lubrication, temperature, and other factors.

Irreversibility is characterized as zero output power flow which implies that all rotating shafts give input power to "produce" the power loss. This is discussed for three as well as four shafts.

The losses considered are specified as tooth losses and planet shaft bearing losses. Other losses might be included but this would not change the results considerably.

It is important to remark that an irreversible gear train with three rotating shafts does not exist. As demonstrated, only under certain rotation conditions will zero output power flow occur. When the sun gear shafts rotate in the same direction, it cannot occur.

Report No. 10, "Torque Distribution, Power Flow, and Zero Output Conditions of Epicyclic Gear Trains," The Institute of Machine Elements, Chalmers Institute of Technology, Gothenburg, Sweden, 1960, 53 pp.

### New Concept of Automotive Gas-Turbine Engine

I. M. Swatman and D. A. Malohn,  
Ford Motor Co.

Assumed performance characteristics and engine configuration for use in trucks. The configuration selected was a two-spool, intercooled, regenerative, reheated cycle. Specific horsepower appeared to approach a maximum at an overhaul pressure ratio of 16:1, and specific fuel consumption appeared to be relatively constant from a pressure ratio of 7:1 to 16:1.

In the sequence of cycle components, the power turbine is placed ahead of the low-pressure compressor turbine. The effect of allowing the power turbine to absorb the majority of the available gas energy results in an independent speed relationship between the high-pressure and low-pressure compressors. The near constant-speed feature of the high-pressure spool combined with an almost constant reheat-burner temperature and varying air-flow characteristics (for varying power requirements) of the low-pressure

spool produces excellent part-load fuel economy.

Future potential appears even more encouraging for this type of power plant. With concerted effort in the area of improving efficiencies of rotating aerodynamic components two per cent over those assumed in the cycle studies, fuel economy can surpass the present diesel engine.

SAE Paper No. 187A, "An Advanced Automotive Gas Turbine Engine Concept," presented at the SAE Summer Meeting, Chicago, June, 1960, 10 pp.

## materials

### Materials Selection Problems For Electronic Components

J. Gray Stuart, General Electric Co.

How radiation and temperature affect the characteristics of electronic components and their materials. The effects of high temperatures on materials have been determined over the years, but the effects of radiation have yet to be fully explored.

There are three interactions that cause damage: Ionization, displacement, and transmutation. Ionization reduces the effectiveness of certain resistors, but it does not affect the conductivity of wire appreciably. Displacement of atoms, as the result of collision with radiating particles, causes materials to become brittle. Transmutation, which is an actual change in the nucleus of an atom, introduces foreign matter that may change the engineering characteristics of the original material. Radiation effects on particular components and materials are:

Germanium Transistor—Loss of amplification.

Glass—Coloring.

Polytetrafluorethylene—Loss of tensile strength.

Polymethyl Methacrylate and Cellulosics—Loss of tensile strength.

Water and Least Stable Organic Liquids—Gassing.

Organic Liquids—Gassing of most stable ones.

Natural Rubber—Loss of elasticity and hardening.

Butyl Rubber—Loss of elasticity and softening.

Polyethylene—Loss of tensile strength. Mineral-Filled Phenolic Polymer—Loss of tensile strength.

Hydrocarbon Oils—Increase in viscosity.

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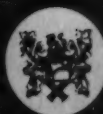
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giving full technical details on Elgiloy. Get this informative literature—convince yourself that Elgiloy Power Springs can be a valuable addition to your product!



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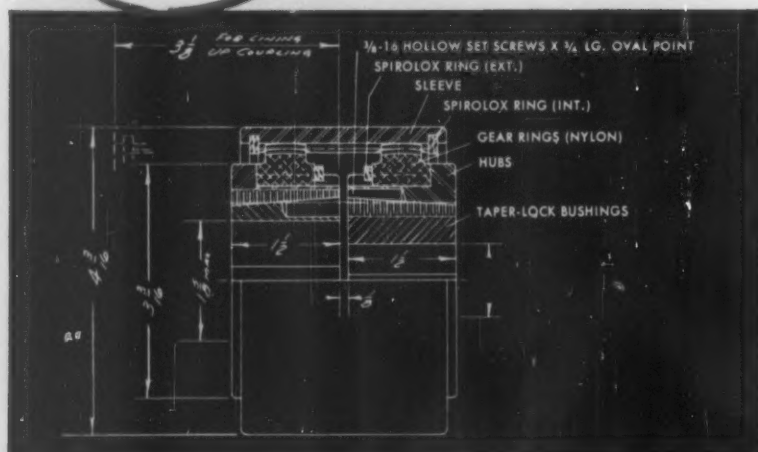
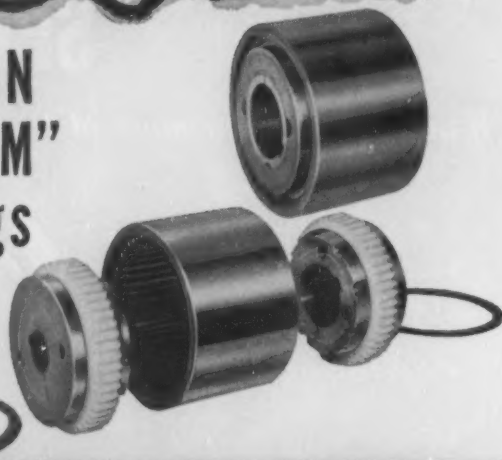


**WATCH COMPANY**

ELGIN, ILLINOIS

# design facts....on

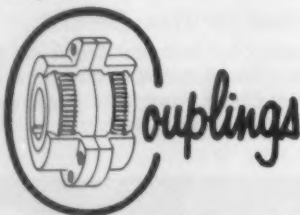
## WALDRON Series "M" Couplings



The new Series M couplings—with nylon gears and steel sleeves—need no lubrication. Equipped with Taper-Lock bushings—each coupling size can accommodate a range of shaft sizes. For instance, the 162M, now available, will take shafts from  $\frac{1}{2}$ " to 1  $\frac{1}{2}$ " with proper size Taper-Lock bushings, and up to 2" without the bushings. Hubs are machined from bar stock and the one piece sleeve is made of steel. This design means a smaller, light weight coupling that is easier to install and maintain and yet can transmit the necessary power. Size 162, Series M gear couplings can be used for continuous operation up to 5000 rpm at torques up to approximately 2000 inch pounds.

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## DESIGN ABSTRACTS

Polystyrene—Loss of tensile strength.  
Ceramics—Reduced thermal conductivity density, crystallinity.  
All plastics—Unusable as structural materials.  
Metals—Most show appreciable increase in yield strength.  
Carbon Steels—Reduction of notch-impact strength, severe loss of ductility, increased yield strength and fracture-transition temperature.  
Aluminum Alloys—Ductility reduced but not greatly impaired.  
Stainless Steels—Increased yield strength, ductility reduced but not greatly impaired.

AIEE Paper No. 60-986, "Design and Development Problems of Radiation-Resistant High-Temperature Tolerant Electronic Equipment Components," presented at the AIEE Pacific General Meeting, San Diego, Calif., August, 1960, 4 pp.

## Correlating Rolling-Contact Fatigue Life and Mechanical Properties of Steels

E. V. Zaretsky and W. J. Anderson, Lewis Research Center, NASA.

Room-temperature fatigue lives of groups of AISI M-1, AISI M-50, Halmo, and WB-49 tool-steel balls, tempered to various hardness levels. Ten per cent life increased continuously with increasing hardness. In contrast, elastic-limit and yield-strength measurements made on bar specimens from the same heats of materials showed optimum values at an intermediate hardness level and so did not correlate with fatigue life. Resistance to plastic deformation, measured with ball specimens in rolling contact, did correlate with fatigue life.

ASTM Paper No. 63, "Relation between Rolling-Contact Fatigue Life and Mechanical Properties for Several Aircraft Bearing Steels," presented at the Sixty-third Annual Meeting of the Society, Philadelphia, June-July, 1960, 17 pp.

## Ablation Cooling

E. R. G. Eckert, Heat Transfer Laboratory, University of Minnesota.

Physical processes involved in ablation cooling and the basis on which to evaluate this method of cooling and the materials used. An object, moving with high velocity, is surrounded by an air layer of extremely high temperature. The heating of the air occurs either by adiabatic compression in a shockwave ahead



of the object or by internal friction within the boundary layer along its sides. No material for the skin of the object can withstand these high temperatures. It must, therefore, be cooled in some way. Consequently, an intensive heat flux will occur from the hot layer into the skin. Part of this heat is immediately removed from the surface by radiation. The rest, however, must be absorbed by some mass with adequate heat capacity—a heat sink. This mass has to be carried along with the vehicle because a utilization of the air outside the heated region as a coolant is difficult or impossible. The heat sink can be a solid material or a material which melts and evaporates or sublimates or is chemically decomposed in the heat absorption process. This cooling method is ablation.

Two experimental tools which contributed most to the development of ablation cooling are the exhaust from a rocket engine and plasma jet which is heated by electric arc discharge. Effective heats of ablation for phenolic or silicone reinforced with refracil are remarkable.

SAE Paper No. 185A, "Ablation Cooling of Missiles and Satellites," presented at the SAE Summer Meeting, Chicago, June, 1960, 12 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 40 cents to members, 80 cents to nonmembers.

ASTM—American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

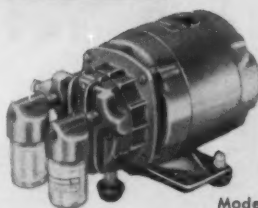
The Institute of Machine Elements, Chalmers Institute of Technology, Gothenburg, Sweden.

ISA—Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

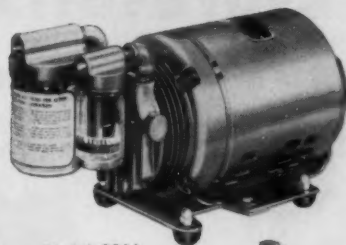
SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y., papers 50 cents to members, 75 cents to nonmembers.

# ROTARY AIR GAST PRODUCTS

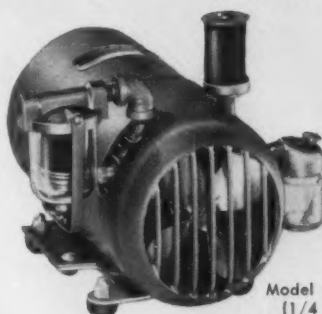
VACUUM or PRESSURE . . .



Model 0406  
(1/12 hp)



Model 0211  
(1/6 hp)



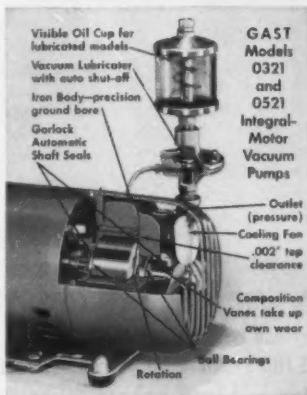
Model 0321  
(1/4 hp)



Model 0521  
(1/3 hp)

For O. E. M., lab or plant use—specify compact, portable integral-motor

## GAST AIR PUMPS



GAST  
Models  
0321  
and  
0521  
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Motor  
Vacuum  
Pumps

Gast construction is precise—and prices are competitive!

To save space . . . and reduce weight and mounting costs—use Gast Integral-Motor-Pump Models! For vacuum use—or fitted as air compressors—four sizes offer capacities from 1/2 to 3.8 cfm.

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Rotary-vane design is positive in displacement, quiet and long-lived. That's why engineers specify Gast Air Pumps as components for air sampling, industrial and laboratory instruments; printing, packaging and vending machines.

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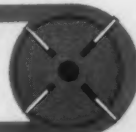
GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

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ROTARY

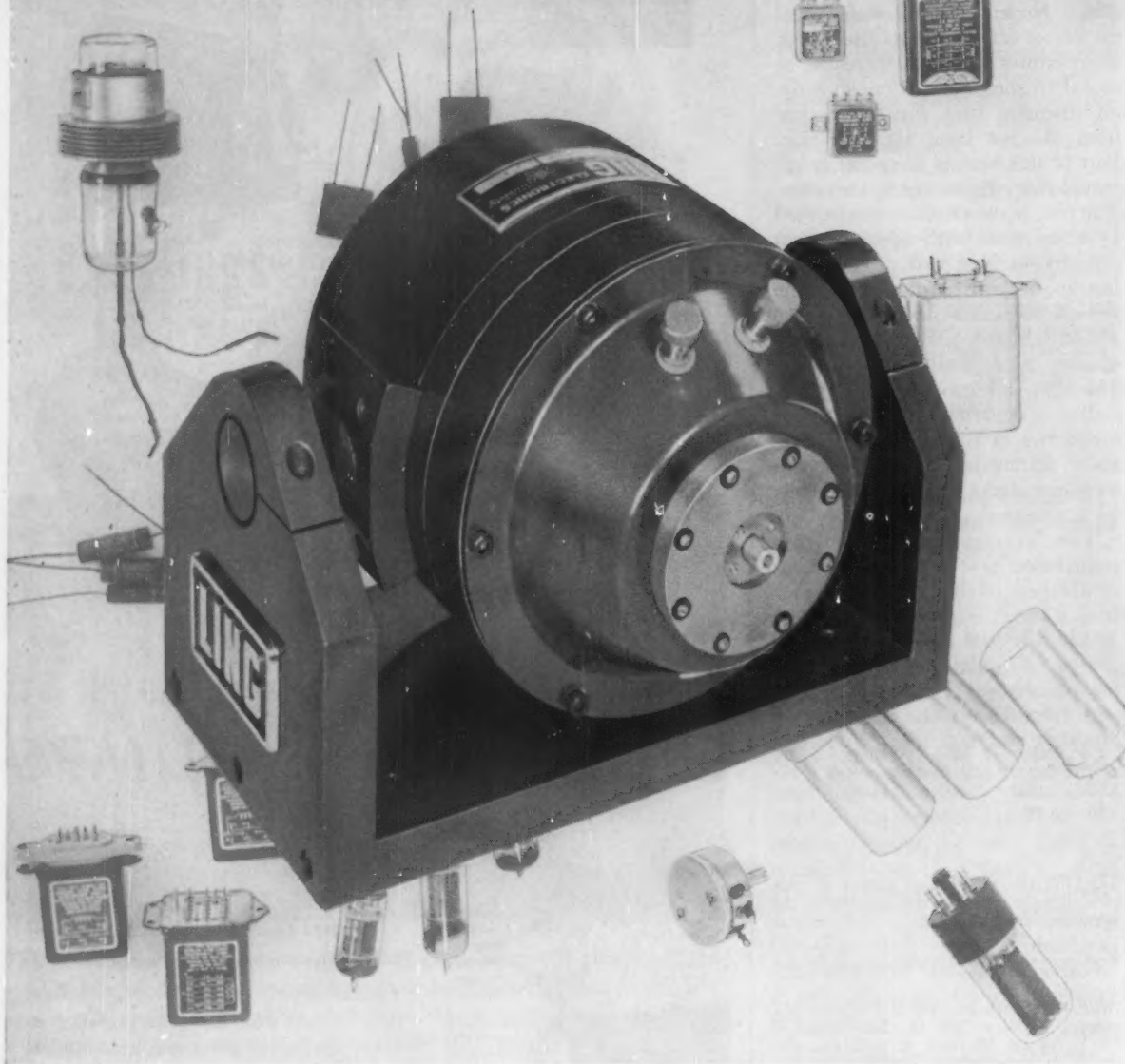
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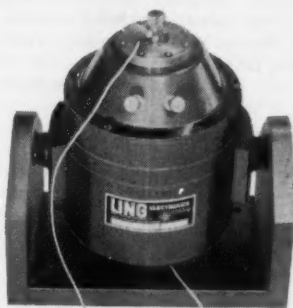
## LING'S NEW PERMANENT MAGNET BABY SHAKER

First of its kind in the country, the new Ling Permag LPM-25 Shaker meets industry's urgent demand for a small shaker for light component testing and back-to-back calibration. With the LPM-25, the manufacturer of electronic tubes and small components can economically give his products a full vibration test, or use as a production quality control. Strict linearity throughout the wide 5-20,000 bandwith (first resonance above 10 kc with one accelerometer) is provided by a unique suspension system. Special features include: Back-to-back calibration up to 100g without special mounting devices, aged permanent magnet, low driving power, excellent linearity, total distortion for 10g 1% over most of the frequency range, shaker trunnion isolation which reduces vibration transfer to supporting structure. Available as a complete laboratory system, ready to plug in and operate. For details on this revolutionary development in vibration testing, write Department MD-5 at our Anaheim address.



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For copies of any literature listed,  
circle Item Number on Yellow Card—page 19

"Do You Talk 'Computerese?'" is a pocket-sized glossary intended to make computer language more intelligible to the layman. It defines 82 terms which have been created in building and using industrial process computers. 22 pages. Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Philadelphia 44, Pa.

Circle 671 on Page 19

Reference guide, Catalog 113, contains information on a complete line of miniature lock nuts and gang channel. All units are shown in pictures and line drawings. Complete engineering specifications are provided, and applications are also included. 36 pages. Kaynar Mfg. Co. Inc., Kaylock Div., Box 2001 Terminal Annex, Los Angeles 54, Calif.

**Circle 672 on Page 19**

New bulletin contains complete physical and electrical characteristics of metal-cased, hermetically sealed, dc oil-impregnated capacitors. Bulletin covers drawn-case "bathtub" types, rectangular-case dual and triple-section types, and compact rectangular-case units that offer maximum capacitance in minimum sizes. Bulletin includes complete listings of available capacitance and voltage-rating combinations. 4 pages. Aerovox Corp., New Bedford Div., New Bedford, Mass.

**Circle 673 on Page 19**

Catalog 1890 fully illustrates and describes a complete line of thermocouple fittings, pressure-sealing glands, and thermocouple accessories. Pictures and cross-sectional views are used to present features, and complete specifications are included. Wire size and resistance table is provided, as well as information on selection of the proper thermocouple. 32 pages. Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.

**Circle 674 on Page 19**

Listed in tabular form in Bulletin 102 are the sizes (lengths and IDs) of all standard precision-bore tubing available in Pyrex glass and the following special glasses: 0120, 1720, 1723, 7052, 7056, 7070, 7520, 7800, Vycor, and Quartz. Precision-bore capillary tubing and square tubing

information is also included. Dimensions apply to Pyrex glass and cover ID, OD, and standard lengths. 4 pages. Wilmad Glass Co., Harding Highway, Buena, N. J.

**Circle 675 on Page 19**

Sedeco TCE series of small electric impulse counters is described in new bulletin. Complete technical data on the three, four, five, and six-digit manual or remote electrical-reset types are furnished, including operating information, electrical data, available types and weights, and dimensional drawings. Special section gives details for operation on ac. 6 pages. Landis & Gyr Inc., 45 W. 45th St., New York 36, N. Y.

**Circle 676 on Page 19**

Form 240-R contains information on stainless and nonferrous castings, with photographs showing many typical castings. Table provides data on stainless castings, including composition of the various alloys, strength, elongation, reduction, and Brinell hardness. List of sizes and weights of stainless-steel sleeves is provided. 6 pages. Vollrath Co., Sheboygan, Wis.

**Circle 677 on Page 19**

New catalog provides much technical data on a line of mechanical slip clutches and brakes, designed for continuous slip. Design and performance characteristics are given, together with typical applications. Section on operation and general information is included, as well as dimensions of the various units. 4 pages. Machine Components Corp., Gazza Blvd., Farmingdale, N. Y.

**Circle 678 on Page 19**

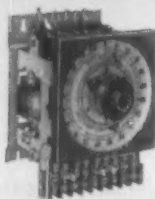
"How to Solve Pumping Problems" contains information about technical problems encountered in pumping. Booklet is divided into three sections: Introduction, which offers a general explanation of rotary-gear pumps and factors involved in pumping problems; three sample problems; and technical data, supplemented by graphs and tables. A chart is also given on the many substances pumped by these units and the type of construction used on each unit. 36 pages. Roper Hydraulics Inc., Commerce, Ga.

**Circle 679 on Page 19**

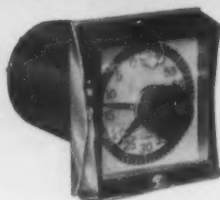


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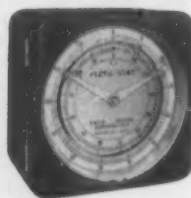
Bulletin 125  
SINGLE CYCLE RESET TIMER



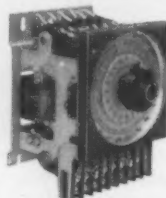
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## HELPFUL LITERATURE

### Fittings and Hose

Bulletin 622 describes Socketless fittings and hose, a quick method of assembling fluid-carrying lines without clamps, lugs, bolts, or sockets. Cutaway drawing illustrates main features of the assembly, and various applications are pictured. Engineering data for the fittings and hose are included. 4 pages. Aeroquip Corp., Jackson, Mich.

Circle 680 on Page 19

### Solid-State Circuits

"Capabilities in Solid-State Circuits" is a two-color, amply illustrated brochure. It includes specifications and characteristics of major items manufactured, including power supplies, ground-support equipment, advanced solid-state equipment, and industrial control systems. 4 pages. Pennon Electronics Inc., 7500 S. Garfield, Bell Gardens, Calif.

Circle 681 on Page 19

### Steel Plate and Sheet

New brochure presents information on Yolo E high-strength, low-alloy steel. Applications are listed and pictured, and examples of intricate fabrication are given. Three classifications of the steel are listed with compositions of each. 4 pages. Youngstown Sheet & Tube Co., Youngstown, Ohio.

Circle 682 on Page 19

### Liquid-Level Gages, Valves

Catalog 376 covers complete line of liquid-level gages and valves with a condensed presentation of the most pertinent data and specifications. Included are dimensional drawings, photographs, construction features, pressure-temperature graphs and ratings, materials, and comprehensive table of sizes, specifications, and standard and optional features. Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

Circle 683 on Page 19

### Leveling Screws

Complete dimensional information on three styles of leveling screws is given in Bulletin 602. Many actual applications are included. Photographs of the three types are provided, with advantages and uses of each pointed out. 6 pages. Ohio Nut & Bolt Co., 33 First Ave., Berea, Ohio.

Circle 684 on Page 19

### Extrusions, Die Forgings

Bulletin provides information and drawings of nonferrous extrusions and die forgings. Hot extrusion and die forgings are described, and their advantages are listed. Table provides data on copper alloys processed by these two methods, listing their nominal compositions. Special metals and alloys that can also be processed are listed. 4 pages. Janney Cylinder Co., 7401 State Rd., Holmesburg, Philadelphia 36, Pa.

Circle 685 on Page 19



## Roller Chain

Form 2600 TF describes Tuf-Flex power-transmission chain for heavy-duty applications. Pictures show how the chain operates and point out special features. Dimensional data and prices are provided. 2 pages. Diamond Chain Co. Inc., 402 Kentucky Ave., Indianapolis, Ind.

Circle 686 on Page 19

## Nylon Pressure Tubing

Brochure provides information on Style 9056 Chemiseal nylon pressure tubing for hydraulic and pneumatic service. Features, applications, and installation instructions are given. Dimensional data and test results are also presented. 2 pages. Garlock Inc., Main St., Palmyra, N. Y.

Circle 687 on Page 19

## Electrical Connectors

Colorful brochure describes Supercon electrical connectors, available in new 25 and 250-amp types in addition to 50 and 100-amp units. Pictures show the assembly procedure, and stock lists of pin plugs, socket plugs, socket receptacles, and pin receptacles are given. 2 pages. Superior Electric Co., 83 Laurel St., Bristol, Conn.

Circle 688 on Page 19

## Tenite Polypropylene

Excellent molding and extrusion characteristics of Tenite polypropylene and its physical, mechanical, electrical, and other properties are explained in "Preliminary Information About Tenite Polypropylene." Booklet also discusses varied uses of the plastic. Charts give typical conditions for both molding and extrusion, and show typical properties of injection-molded articles. 8 pages. Eastman Chemical Products Inc., Kingsport, Tenn.

Circle 689 on Page 19

## Load-Bearing Nut

New brochure describes and pictures P37 P-Nut which provides a solution for attaining load-bearing threads in ductile sheet metal. Cutaway drawings are utilized to point up salient features, and line drawings and tables provide dimensional data. Additional material includes list of advantages, test results, and shows how to install the unit. 2 pages. Hi-Shear Rivet Tool Co., 2600 W. 247th St., Torrance, Calif.

Circle 690 on Page 19

## Flow-Rate Alarms

Bulletin 175 gives details and examples of flow-rate alarms to provide signalling and simple control functions. Units are pictured, and specifications and features are included. 4 pages. Brooks Rotameter Co., P. O. Box 432, Hatfield, Pa.

Circle 691 on Page 19

## Environmental Chambers

Brochure 600 contains latest data on environmental testing and other applications for controlled atmospheric conditions. An outstanding feature is a pictorial color chart summarizing the latest-known data at altitudes from sea level to

## HELPFUL LITERATURE

2,000,000 ft. Other charts give technical information on atmosphere, temperature, and humidity. Brochure includes a review of nine main environmental applications, and presents details on 13 types of environmental chambers and low-temperature freezers. 32 pages. Webber Mfg. Co. Inc., P. O. Box 217, Indianapolis, Ind.

Circle 692 on Page 19

## Control Valves

Data Sheet 101 provides features of construction and complete specifications on Series LB control valve, a single-seated, split-body valve with pneumatic cylinder actuator and built-in positioner. Sheet lists a variety of optional actuators and accessories which make the valve suitable for any control-valve application. Cross-section of the valve is used to describe the special features. 2 pages. Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.

Circle 693 on Page 19

## Steel Couplings

Catalog FT-60 provides information on JIC flared-tube and dryseal pipe fittings. All engineering data and picture are provided for each type of unit. Special features are shown through use of a cutaway drawing. 6 pages. L & L Mfg. Co., 21590 Hoover Rd., P. O. Box 397, Warren, Mich.

Circle 694 on Page 19

## Secondary Batteries

Illustrated brochure describes physical, electrical, and typical application characteristics of rechargeable Silvercel, silver-zinc secondary batteries. Graphs illustrate the electrical characteristics and compare them with those of conventional battery systems. Brochure also contains scale cell drawings and photographs of applications. 10 pages. Yardney Electric Corp., 40-50 Leonard St., New York 13, N. Y.

Circle 695 on Page 19

## Lip Seal

Form 491 presents information on the Dura lip seal for use in handling abrasive fluids and slurries. Unit is pictured and shown in line drawing, and important features are pointed up. Dilution curve chart and diagram showing a pressure regulator and flow meter for lip-seal applications are included. 2 pages. Durametallic Corp., Kalamazoo, Mich.

Circle 696 on Page 19

## Trimmer Potentiometers

New product bulletin contains descriptions of FilmPot precision trimmer potentiometers used for trimming or circuit-balancing applications where infinite resolution and high-temperature characteristics are needed. It also includes a power rating curve for continuous duty, outline drawings, complete performance data, an adjustment schematic, and prices and availability. 2 pages. Fairchild Controls Corp., Components Div., 225 Park Ave., Hicksville, L. I., N. Y.

Circle 697 on Page 19

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Circle 513 on Page 19





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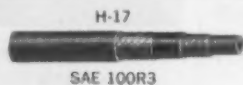
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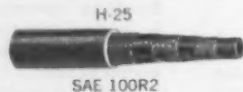
### LOW PRESSURE



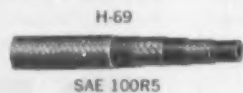
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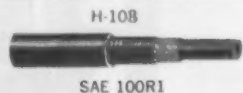
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### MEDIUM HIGH PRESSURE



### MEDIUM HIGH PRESSURE



### HIGH PRESSURE



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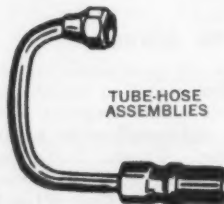
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MACHINE DESIGN

## Miniature Connectors

Form 2500-560 describes Continental removable, crimp-termination contacts for solderless wiring. These are for use with Series 2500 miniature rectangular connectors. Method of insertion and removal of the contacts is shown. Outline and mounting dimensions for the connectors are provided. Outlines of guides and screw locks are also included. 6 pages. DeJura-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 698 on Page 19

## Fan Motors

Illustrated Bulletin GEC-219F discusses applications and features of improved 51-frame, unit-bearing, totally enclosed fan motor. Publication describes advanced lubrication, bearing, and insulation systems on the 3½-in. diameter motors. Tables on motor ratings, sizes, fan blades, motor dimensions, and operating data are also included. 4 pages. General Electric Co., Schenectady 5, N. Y.

Circle 699 on Page 19

## Tubing Selection

Selection of steel tubing according to type, finish, analysis, formability, machinability, weldability, and relative cost is made easy through Technical Bulletin 12-10. Comparative listing includes characteristics of seamless and welded round, square and rectangular tubing for mechanical, hydraulic-cylinder, fluid-line, and structural applications. Elements such as size range, wall thicknesses, and stock lengths, along with ability of tubing to develop added strength and hardness through heat treatment, are also included. 4 pages. Joseph T. Rverson & Son Inc., Box 8000-A, Chicago 80, Ill.

Circle 700 on Page 19

## Alloy Fasteners

New bulletin lists threaded fasteners including step-studs, bolts, screws, and hardware items meeting AN, NAS, and MS requirements. Simplified, unusual AN-chart is included in each catalog. 22 pages. Mercury Air Parts Co. Inc., 9310 W. Jefferson Blvd., Culver City, Calif.

Circle 701 on Page 19

## Fluids and Lubricants

Booklet F-6500F contains comprehensive data on the 32 types of Ucon synthetic fluids and lubricants available. Included are physical properties, physiological properties, physical and chemical analytical methods, storage and handling instructions, and section on the selection of the proper fluid or lubricant for any given application. Many charts and tables are utilized. 52 pages. Union Carbide Corp., Union Carbide Chemicals Co. Div., 30 E. 42nd St., New York 17, N. Y.

Circle 702 on Page 19

## Cable and Wire

"Multi-Conductor Cable and Hook-up Wire," covering Teflon TFE, Teflon FEP 100, and PVC, describes wide design and engineering capabilities, including round and ribbon cables and assemblies. Catalog

## HELPFUL LITERATURE

describes full lines of Teflon wire and Teflon FEP 100 hook-up wires. Easy reference sections provide much useful background information on various conductors and insulating materials. 18 pages. International Silver Co., Times Wire & Cable Div., Wallingford, Conn.

Circle 703 on Page 19

## Mountings, Mounting Systems

Bulletin 905 is a comprehensive, illustrated guide to resilient mountings and mounting systems. It includes general design, application, and performance data for 22 products. Bulletin can be used in primary selection of the right bonded-rubber mounting or flexible mounting system for any particular job. 8 pages. Lord Mfg. Co., Erie, Pa.

Circle 704 on Page 19

## Self-Locking Nuts

Form 2339 describes Flexloc self-locking nuts for industrial applications. Information is included on operation, uses, materials, finish, strength and capacity, reusability, and torque. Chart provides pictures of the various models, materials used, and sizes available. 6 pages. Standard Pressed Steel Co., Industrial Fastener Div., Jenkintown, Pa.

Circle 705 on Page 19

## Throttle Valves

Bulletin 460 illustrates and describes line of Le-Hi Series 2500 throttle valves for safe control of compressed air on pneumatic-operating equipment. All units are pictured, with break-away photograph used to point out important features. Size information is provided. 4 pages. Hose Accessories Co., 2720 N. 17th St., Philadelphia 32, Pa.

Circle 706 on Page 19

## Adjustable-Speed Drives

Two new bulletins describe Sizes 1 and 2 of Series 35 electrical adjustable-speed drives. Bulletins contain complete specifications, design and construction details, operational, installation, and application information. Sketches show a wide variety of system variations. Modular design of the drives permits flexibility of application. Bulletin SL-351-460 describes Size 1 for drives to 1/3 hp, and Bulletin SL-352-560 describes Size 2 for drives to ¾ hp. 16 pages. Cleveland Machine Controls Inc., 1155 Brookpark Rd., Cleveland 9, Ohio.

Circle 707 on Page 19

## Kennametal and Kentanium

More than 75 "Proven Uses of Kennametal and Kentanium" are illustrated in Booklet B-666. Booklet includes records of wear resistance to 100 times that of steel, high resistance to impact, deformation, corrosion, and oxidation at temperatures of 2200 F and above. Cost-saving applications in more than 25 industries are described. 24 pages. Kennametal Inc., Latrobe, Pa.

Circle 708 on Page 19

## PREMIUM CHAIN ...NO EXTRA COST



Rex Roller Chains are designed to give you longest possible wear life. For example, as shown above, all standard roller chains have oil holes in the bushings to assure easy penetration of life-adding lubricant to the important pin-bushing contact area...a vital factor, particularly on high-speed drives. You get many more cycles of wear life...a PLUS VALUE premium chain at no extra cost. For complete information, mail the coupon.

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Circle 515 on Page 19



Modern board forging hammer

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By designing the shifter fork of his transmission to be forged, a manufacturer of earthmovers eliminated costly equipment breakdowns in the field because of fork failure. Factor of safety was increased even while weight and over-all costs were being decreased.

Parts scrapped because of voids uncovered after much high-cost machining are eliminated... forgings are *naturally* sound all the way through. Forgings start as *better* metal... are further *improved* by the compacting hammer-blows or high-pressure of the forging process.

Design your parts to be forged... increase strength/weight ratio, reduce as-assembled cost, improve performance. Literature to help you design, specify, and procure forged parts is available on request.

When it's a vital part, design it to be



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## Directional Valves

New bulletin provides information on Pilotair valves, panel-mounting type. Various models are shown, with outline dimensions, diagram symbol, and other pertinent data. General information on the entire line, such as design, materials used, operating limits, and capacity, is provided. 8 pages. Westinghouse Air Brake Co., Industrial Products Div., Wilmerding, Pa.

Circle 709 on Page 19

## Temperature Regulators

Catalog J180-1 contains full information on complete line of sliding-gate and plate-temperature regulators designed for use on steam, water, air, oil, gas, or chemicals. Units are illustrated by photographs, cross-sectional drawings, and line drawings. Accessory items are also described. Catalog includes features, applications, sizing charts, flow curve, sample specifications, and complete engineering information. 8 pages. OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

Circle 710 on Page 19

## Teflon TFE and 100 FEP

New color bulletin describes the properties and applications of Teflon TFE and 100 FEP. Charts provide engineering data, and pictures of various products are also included. 4 pages. Industrial Plastics & Equipment Co. Inc., 477-48 Main St., Orange, N. J.

Circle 711 on Page 19

## Shaped Wire

Catalog DH-1226-A covers facilities for providing wire of various analyses pre-shaped to a desired cross-section. It also contains helpful information on methods of calculating areas of common shapes, physical properties of steel wire, table of standard wire gages, and hardness conversion tables. 16 pages. American Chain & Cable Co. Inc., Page Steel & Wire Div., Monessen, Pa.

Circle 712 on Page 19

## Plug and Receptacle Connectors

Catalog HYF 60 describes complete line of plug and receptacle connectors featuring crimp-type, snap-locked contacts. Hyfen selector chart details many significant characteristics and features of each family of connectors. Technical discussion of plating types and specific applications for each type is included. Charts, photographs, and technical drawings are among the complete data presented. 52 pages. Burndy Corp., Omaton Div., Norwalk, Conn.

Circle 713 on Page 19

## Sound Control

Increasing efficiency and productivity by preventing noise is the subject of "Sound Control." Catalog illustrates typical sound-control applications with illustrated graphs showing reduction of noise in decibels and also reduction of noise distinguished by the human ear. Charts show flow rates and operating specifications, and photographs and explanations describe how

## HELPFUL LITERATURE

sound control is obtained with new silencer. Typical applications of the silencer are given. 12 pages. Allied Witan Co., 12500 Bellaire Rd., Cleveland 35, Ohio.

Circle 714 on Page 19

## Nylon Bobbins and Washers

New brochure on nylon bobbins and thrust washers outlines complete bobbin specifications on maximum and minimum flange and core sizes, core lengths, and wall thicknesses. Bobbins size chart, washer size chart, and folder on Zytel nylon are included. 4 pages. Cosmo Plastics Co., 3239 W. 14th St., Cleveland 9, Ohio.

Circle 715 on Page 19

## Rotating-Shaft Seals

Illustrated Brochure 660 presents much information on the various types of rotating-shaft seals. Included are O-ring, double-face cartridge, grommet, boot, metal bellows, and labyrinth seals. All engineering specifications are given for each type, along with explanation of operation and construction, and recommended uses. Typical designs are shown for each type. Liberal use is made of illustrations, line drawings, graphs, and charts. Section on mating rotors and rotor designs is included. 34 pages. Cartriseal Corp., 3515 W. Touhy Ave., Lincolnwood, Ill.

Circle 716 on Page 19

## Stainless-Steel Tubing

New brochure is a guide to stainless products. Cut-away views of tubing illustrate fine finish obtained. Charts show size range, analyses, and standard tolerances. Information about testing facilities is outlined. 4 pages. Columbia Steel & Shafting Co., Summerill Tubing Co. Div., Pittsburgh 30, Pa.

Circle 717 on Page 19

## Metal Powder Parts

"Designing for Pressed Brass and Nickel Silver Metal Powder Parts" contains two sections. The first provides a great deal of general information about current materials, methods, and practical design considerations. The second section contains 27 case histories of specific applications, showing how the design factors outlined have been used in many different products. 24 pages. Write on company letterhead to New Jersey Zinc Co., 160 Front St., New York 38, N. Y.

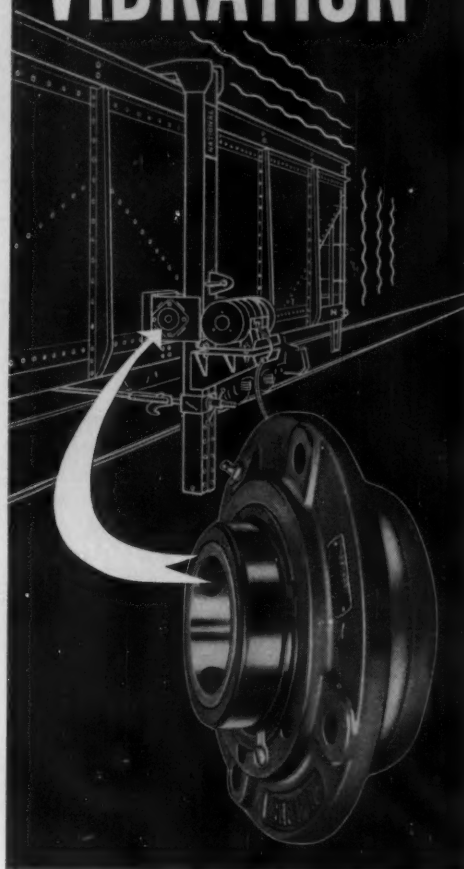
## Valves and Fittings

Catalog 60 provides information on the O-Seal system of valve and fitting design. General material on the system gives details of its operation and important features. Large cross-sectional views and line drawings are utilized. Units in both 6000 and 1500-psi series are listed, with dimensional drawings and size information included. Section of engineering data contains material on dieseling, O-rings, boss details, and braze ring and grooves. 36 pages. Write on company letterhead to Combination Pump Valve Co., 851 Preston St., Philadelphia 4, Pa.

Circle 517 on Page 19→  
213

Another **PLUS** value...

## BUILT TO TAKE VIBRATION



Even under car-shaker vibration that loosens tons of coal, Shafer Bearings keep their steel grip on longer life.

This reserve stamina stems from exclusive bearing design and precision construction. Concave rollers matched to convex raceways are of highly elastic, case-hardened alloy steel. With every shock, rollers compress, increasing bearing surfaces.

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( ) Please send Shafer Bearing Catalog 59A.

Name.....

Company.....

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City..... Zone..... State.....



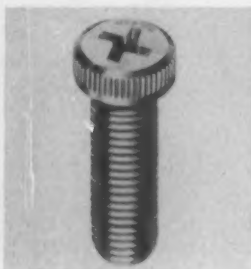
# New Parts and Materials

Use Yellow Card, page 19, to obtain more information

## Cap Screw

has low head with  
high-torque recess

Cap screw utilizing Aer-O-Torq recess for high torque strength is now available. Because the recess requires less metal for a given necessary driving torque, screw actually has less metal in the head, and head is up to 35 per cent shorter than other units. Screws torque higher, distribute the load over wider bearing surfaces, and provide more wrenching power and clamping force without indenting the fastened



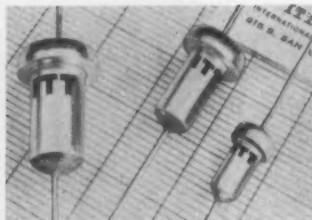
material. Feature of the recess is perfect engagement with the driver at all times, resulting in even distribution of the driving torque. Low contour of the head of the screw enables it to be used in hard-to-get-to places. Aer-O-Line Mfg. & Supply Co., 3110 Winona Ave., Burbank, Calif.

Circle 718 on Page 19

## Tantalum Capacitors

for working temperatures  
to 85 C

Missile, airborne, and mobile services are the application areas of wet-anode tantalum capacitors (M-type). They are designed to serve in working temperatures to 85 C. Available in three case sizes, units provide capacitance range from 1.75 to 330 mf over a working-voltage



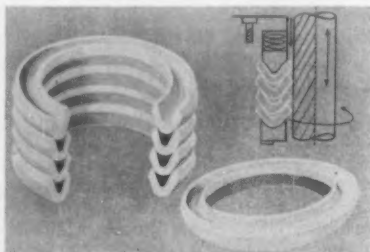
range to 125 v dc and maximum surge voltages to 140 v dc. Sintered tantalum slug in a fine-silver case results in compactness and ability to withstand rugged service, with 2000-hr life at maximum temperature and working voltage. Units are guaranteed to 80,000 ft and accelerations to 20 g if limited to 0.1 in. in the range of 50 to 2000 cps. Components Div., International Telephone & Telegraph Corp., 815 San Antonio Rd., Palo Alto, Calif.

Circle 719 on Page 19

## V-Type Seals

have maximum  
plastic memory

Fluorlastic V-Seals have excellent chemical and mechanical properties of Teflon and possess greater resiliency and toughness. Because the seals are molded under ambient temperatures approximating those under which they will perform,



they have a maximum plastic memory with minimum dimensional distortion. They maintain dimensional accuracy over a wide range of pressures from 0 to 1000 psig and tem-

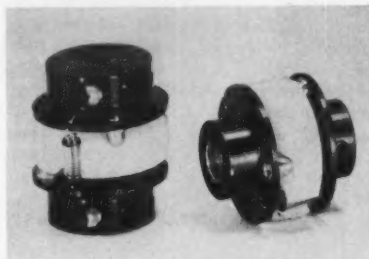
peratures from -350 to +500 F. Self-lubricating seals have lowest coefficient of friction of any solid, 0.02, and have nonstick-slip action. They have met specifications for zero leakage in rotating shaft seals for jet-engine application. Seals are completely resistant to all solvents, fuels, oils, and chemicals. Joclin Mfg. Co., Lufbery Ave., Wallingford, Conn.

Circle 720 on Page 19

## Adjustable Slip Clutches

are compact and lightweight

Two friction clutches are used to protect components against excessive or inertia shock loads. Type ASC-1 has over-all dimensions of  $\frac{7}{8} \times 1$



in., and miniature type ASC-2 is  $\frac{5}{8} \times \frac{5}{8}$  in. in size. Features of the clutches are compactness, light weight, and adjustability over a wide torque range without the need for removal from a system. Technology Instrument Corp., 531 Main St., Acton, Mass.

Circle 721 on Page 19

## Microminiature Relays

employ interlocking  
preformed precision parts

Precision microminiature relays are approximately the size of a postage stamp and weigh only  $\frac{1}{2}$  oz. Relays employ an interlocking design of only ten preformed precision parts, permitting automated mass

# Tests point way to efficient high-speed drives

the BIG

**PLUS** value

In many chain drive applications, machine designers are seeking more efficient ways to handle higher speeds and greater horsepower. Foreseeing this trend, CHAIN Belt engineers began an intensive program of research into the effects of greater speeds and horsepower on chain life.

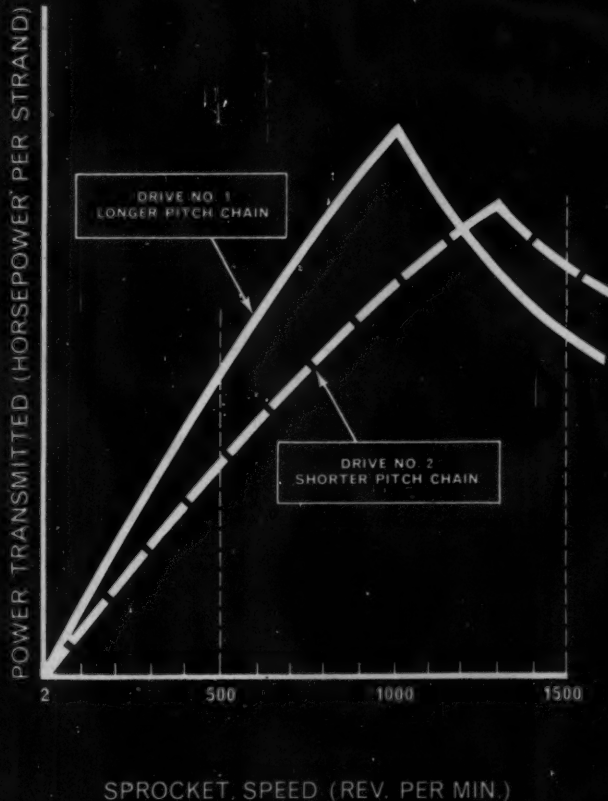
Thousands of hours' testing gave definite evidence that new concepts of chain selection were needed in the higher speed ranges. *Shorter* pitch chains were proved to have more horsepower capacity than longer pitch chains at higher speeds. As the chart above shows, the horsepower capacity of a given pitch chain increases to a peak at a definite point in the r.p.m. of the sprocket. Beyond this point, the h.p. capacity of the bushing and roller decreases. But this point is higher for the shorter pitch chain than for the longer. The heavier link plates in the longer pitch chain (Drive No. 1) enable it to handle a greater load at 500 r.p.m. than the shorter pitch chain. At 1500 r.p.m., however, the shorter pitch chain handles a much heavier load.

In any given application, there is an optimum pitch and sprocket size that should be used. CHAIN Belt engineers, through their exhaustive testing program, have made determinations that assure the right choice of chain for each type of service. If you have a problem involving higher speed power transmission, we suggest you have your CHAIN Belt man review your requirements. Write CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wis.

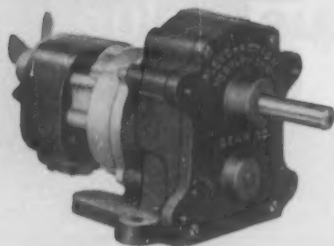
**REX**  
CHAIN BELT COMPANY

Circle 518 on Page 19

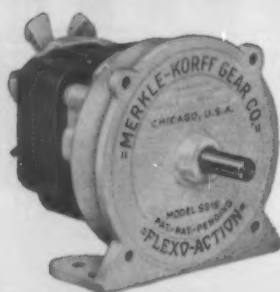
## HORSEPOWER CHART FOR ASA ROLLER CHAIN



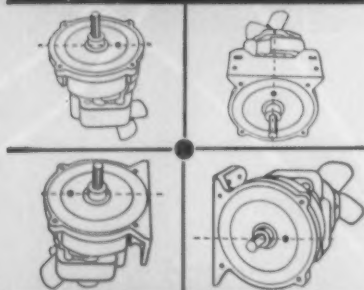
**MORE POWER  
IN LESS SPACE**



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PER POUND**



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OF TORQUE**



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All motor types. RPM from fractional to 300. Torques from 300 lb.-in. to 4. Rugged, long life, precision hobbled gearing.

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Chicago 7, Illinois  
MOORE 6-1900

Circle 519 on Page 19

**NEW PARTS AND MATERIALS**



production with greatly increased reliability and resistance to shock and vibration. The DPDT units are available in 2 and 10-amp and dry-circuit ratings. Nine standard can styles and four terminal styles are furnished. Units operate over ambient temperature range of -65 to +125 C. **Control Dynamics Corp.**, North Hollywood, Calif.

Circle 722 on Page 19

**Universal Joints**

are stainless steel,  
 $\frac{3}{8}$  to 2-in. diam units

Most frequently used sizes of universal joints are now available in stainless steel from stock. Selection



includes solid or bored types in 10 sizes from  $\frac{3}{8}$  to 2-in. diam, and  $1\frac{3}{4}$  to 5  $\frac{7}{16}$  in. over-all lengths. **Boston Gear Works**, Quincy 71, Mass.

Circle 723 on Page 19

**Internal Expanding Brakes**

for live or  
stationary axles

Internal expanding 5-in. brakes are suited to installation on standard small gasoline engines or motors, for power mowers, lawn sweepers, portable elevators, and golf carts. Brakes are economically-priced, space-saving, and can be used on either live or stationary axles. Brakes lend themselves to varied methods of installation, depending upon preference and vehicle construction. Brake is actuated by a

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**SERIES W**



**General  
Purpose  
Relays**

**MEASURE ONLY:**

$1\frac{1}{2}$  " x  $1\frac{1}{2}$  " x  $1\frac{1}{4}$  "

**BUT CARRY:**

to 25 A. resistive at 115-230 V., A. C.; 1 h.p., 125 V., 2 h.p., 250 V., A. C.; D. C. and other higher ratings on request.

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**MOUNTINGS:**

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"Diamond H" engineers are prepared to work out variations of these rugged, dependable relays to meet your specific requirements in such applications as **automation controls, appliances and air conditioning equipment**, or what you will. Just ask.

**THE  
HART**

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Circle 520 on Page 19



# New

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your free copy, write us today on your company letterhead, giving name and title. Formica Corporation, a subsidiary of American Cyanamid, 4514 Spring Grove Ave., Cincinnati 32, Ohio.



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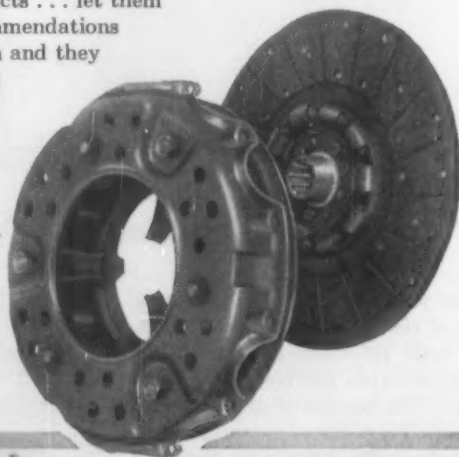
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ROCKFORD CLUTCH DIVISION

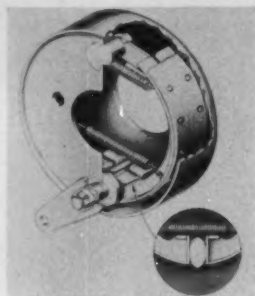
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311 CATHERINE STREET  
ROCKFORD, ILLINOIS



Export Sales  
Borg-Warner International  
36 So. Wabash, Chicago, Ill.

### NEW PARTS AND MATERIALS



lever and linkage system. Brake drum can be welded or fastened to the sprocket, wheel hub, or adapted flange with cap screws; it revolves around the stationary brake mechanism fastened to the axle. Brakes are available in a variety of different bores and widths. Magneto and Engine Accessories Div., Fairbanks, Morse & Co., Beloit, Wis.

Circle 724 on Page 19

### Wire and Cable Strapping

for unsupported wire and cable in any diameter or form

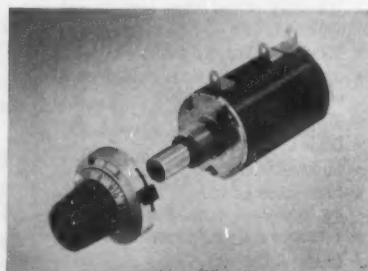
Insuloid Strapping consists of two components, a high-grade PVC plastic belt with conveniently spaced mounting holes, and a stud-like insert. Strap is simply wrapped around the wire or cable run to be held and a stud is snapped in. System can be used quickly to secure or group all types of unsupported wire and cable in any diameter or form, without waste. Strapping is available in 75-ft coils, 5/16 and 1/2-in. widths. Electrovert Inc., 124 E. 40th St., New York, N. Y.

Circle 725 on Page 19

### Potentiometer and Dial

with standard resistances of 10 to 125,000 ohms

Model 7216 is a 10-turn, 7/8-in. diam precision potentiometer with standard resistances of 10 to 125,000



## GREATER RUN-IN PROTECTION EXTENDS PISTON LIFE OF CURTISS-WRIGHT ENGINES

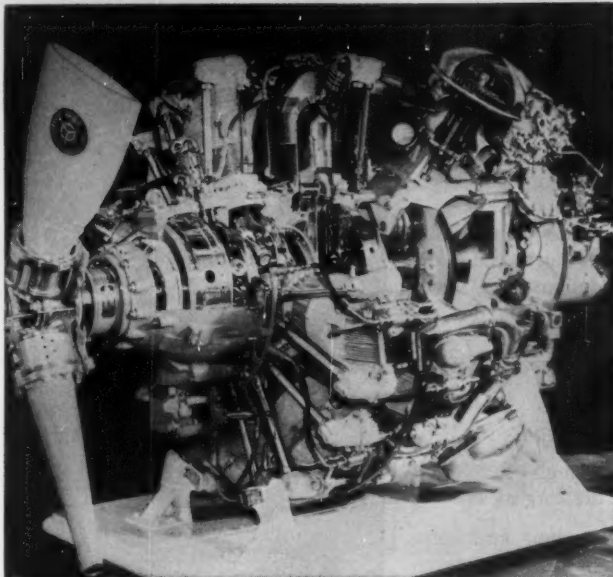


Photo courtesy of Curtiss-Wright Corp.

Curtiss-Wright Corporation's Wright Aeronautical Division, located at Wood-Ridge, N.J., has extended the "life span" of pistons used in their radial reciprocating airplane engines. By coating piston skirts with 'dag' 213 — a dispersion of graphite in an epoxy-resin binder — they are protected against scuffing, scoring, galling, and seizing during the critical running-in period.

Where previously Curtiss-Wright engineers had used finely powdered graphite and phenolic resin, they found that 'dag' 213 was more uniform in consistency and had better adhesion . . . was actually adsorbed by the surface to form a more durable, corrosion-resistant film that became virtually integral with the metal. Due to the heat-transmission properties of 'dag' 213, the coefficient of friction is kept at a uniform minimum to assure free action and proper wear-in characteristics. The exacting clearances in reciprocating engine design make the run-in process so critical that perfect friction and heat control must be maintained under the speeds and loads required. In addition, the graphoid surface takes over the job of supporting the load if the liquid lubricant ruptures momentarily during run-in, thereby preventing metal-to-metal contact until the oil film re-establishes itself.

'dag' 213 is spray-applied at Curtiss-Wright with conventional spray equipment. After the piston skirts are coated, the pre-assembled pistons are oven-heated at 350°F for 2½ to 3 hours. Fabrication and treatment techniques used at Curtiss-Wright permit a high degree of accuracy in maintaining piston and cylinder wall tolerances. Only forged aluminum alloys are used for these pistons which operate within nitrided steel cylinder walls. The application of Acheson's 'dag' 213 has been extended to all models of Curtiss-Wright engines in both their 18 and 9-cylinder categories. Investigate the use of an Acheson Dispersion in your own assembly or run-in application. Write Dept. MD-80.



**ACHESON Colloids Company** PORT HURON, MICHIGAN

A division of Acheson Industries, Inc. Also Acheson Industries (Europe) Ltd. and affiliates, London, England

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## New Literature Describes Assembly and Run-in Uses

The value of Acheson Dispersions as additives in assembly and run-in lubricants is described in easy-to-read form in a recently printed brochure, Bulletin 421. A copy for your personal file is available immediately upon request.

It covers the many advantages Acheson customers are gaining in these critical applications by using colloidal dispersions which:

1. Provide smoother bearing surfaces through control of the wear rate.
2. Permit closer tolerances due to their microscopic, flat particle size.
3. Allow increased power because of reduced friction.
4. Lower bearing temperatures.
5. Increase the affinity of mating metal surfaces for oil.
6. Lessen oil consumption.
7. Shorten the period necessary for run-in.
8. Protect against momentary oil failure.
9. Lower maintenance and replacement costs.
10. Insure a longer, more trouble-free equipment operating life.

If you are concerned with the design or manufacture of engines, motors, bearing assembly, or machinery, Bulletin 421 should prove of interest to you. The vital contribution which Acheson Dispersions of colloidal graphite or molybdenum disulfide make in safeguarding against excessive wear during running-in, is a matter of record. Also, Acheson dry film lubricants, used in assembly press fit applications, are providing effective lubrication without sacrificing the tolerances involved. Send for your copy of Bulletin 421, "For Assembly and Run-in Lubrication".



'dag' is a trademark registered in the U.S. Patent Office by Acheson Industries, Inc.

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### for WARMING and DRYING

Heinze Blower-Heaters provide continuous operation on applications such as hot food vending machines; photographic dryers; plate and food warmers. Heater wattages are available in single ratings from 200 to 1200 watts. Heater can be thermostatically controlled through separate terminals. Coiled wire heating element is well insulated to protect outer walls.

DH model includes Type D 2 pole shaded pole induction motor. YH model is powered by Type Y 4 pole shaded pole induction motor. Single units deliver 55 cfm; double units, 100 cfm. Motors are cw or ccw, 115V or 220V, 60 cycle, 1 ph. Choice of mountings.

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SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

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Circle 524 on Page 19

#### NEW PARTS AND MATERIALS

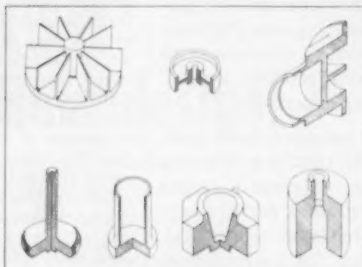
ohms and  $\pm 0.5$  per cent standard linearity. Associated  $\frac{7}{8}$ -in. diam turns-counting dial is also offered to users desiring a precision potentiometer-dial package. Potentiometer has  $\frac{1}{4}$ -in. diam shaft and No.  $\frac{3}{8}$ -32 bushing mount. It is rated 2 w at 25 C, derating to zero at 85 C, with a minimum operating temperature of -55 C. Potentiometer has a molded diallyl-phthalate housing, bronze front lid, and stainless-steel shaft. The 2600 series turns-counting dial counts full turns and hundredths of each. Helipot Div., Beckman Instruments Inc., 2500 Fullerton Rd., Fullerton, Calif.

Circle 726 on Page 19

#### Complex Metal Shapes

are obtained through extrusion and die forging

Wide variety of various and complex metal shapes can be produced by methods employing cold or hot extrusions, or by hot die forging.



Among the many advantages of these processes are flexibility of design, improved physical properties, reduced machining operations due to closely held tolerances, and high productivity. In addition, porosity and chip loss are eliminated. Copper-alloy materials and such metals or alloys as beryllium, beryllium copper, columbium, titanium, zirconium, zinc, and other metals can be shaped by advanced methods of extrusion and die forging. Janney Cylinder Co., 7401 State Rd., Philadelphia 36, Pa.

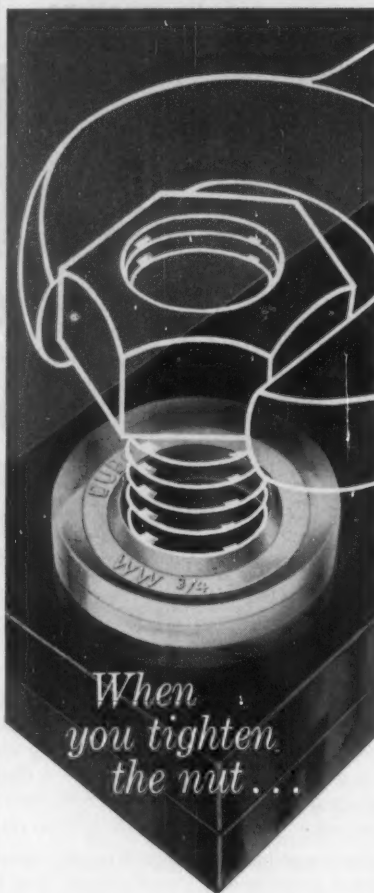
Circle 727 on Page 19

#### Hydraulic Cylinders

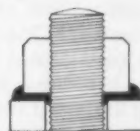
for 3000-psi operation

All-steel hydraulic cylinders are available in bore sizes of  $1\frac{1}{8}$  through 12 in. in all standard

This new lock and seal washer is just plain **REVOLUTIONARY...**



#### NYLOGRIP Dubo Lockwasher locks and seals it-instantly!



Patents Applied For

The new NYLOGRIP Dubo Lockwasher is made of a special, cold-flow plastic called Nylon 6. When the nut is tightened, the washer "flows" — its inner diameter grips into the threads of the nut and bolt, to seal this junction against leakage, while the outer diameter flows over the outer edges of the nut, seals and locks it... so tight neither shock nor vibration can budge it! The Dubo Lockwasher can be used time and again without the slightest loss of holding power. And, because it's symmetrical and has no threaded parts, you couldn't fit one incorrectly if you tried.

**PLUS FEATURES:** excellent electrical properties... exceptional wear resistance... good shock absorption... resists corrosion, chemicals... non-flammable... high flexural strength.

**PLUS USES:** The excellent electrical characteristics of NYLOGRIP Dubo Lockwashers make them ideal for electrical insulation, or to help control electrolytic corrosion between dissimilar metals.

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Non Metallic Fastenings of all types.

Circle 525 on Page 19



... MICROMETER SETTING

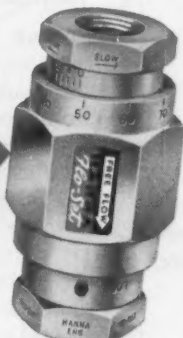
*For Exacting Flow Control*

**HANNA**  
*Flo-Set*  
**VALVES**



*Flo-Set 1000*

Hydraulic pressure  
to 1000 psi  
Sizes  $\frac{1}{4}$ ",  $\frac{3}{8}$ ",  
 $\frac{1}{2}$ ",  $\frac{3}{4}$ "  
Temperatures  
to 250°F



*Flo-Set*

Air, Oil, water  
operation to 250 psi  
Sizes  $\frac{1}{4}$ ",  $\frac{3}{8}$ ",  
 $\frac{1}{2}$ ",  $\frac{3}{4}$ "  
Temperatures  
to 250°F



**FOR AIR • OIL • WATER • OTHER FLUIDS**

**R**EGULATING cylinder speeds or controlling fluid flow of air, oil or water is so simple with Hanna Flo-Set Valves... you need only turn the valve body one revolution to adjust from zero to full pipe capacity. Micrometer-type graduations are numbered to indicate the percentage of pipe capacity. Once set, the position can be locked to avoid accidental change. Future resetting to a predetermined flow requires no guesswork.

Hanna Flo-Set Valves allow full flow in one direction—controlled flow in the opposite. Used in pairs, they regulate independently cylinder instroke and outstroke speeds. Hanna Flo-Set Valves assure uniform speed, smoother action and improved performance of cushioned and non-cushioned cylinders.

Valve sizes are  $\frac{1}{4}$ ",  $\frac{3}{8}$ ",  $\frac{1}{2}$ ", and  $\frac{3}{4}$ "... a  $\frac{1}{4}$ " Jr. model, without graduations or locking collar, is available for light piping and tubing.

Whatever your problem of precision fluid control may be—you will find the best answer in Hanna Flo-Set Valves—designed, built and guaranteed by Hanna's 50 years of experience in hydraulics and pneumatics.

**OTHER HANNA VALVES**  
Include solenoid, pilot, hand  
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**Hanna Engineering Works**

HYDRAULIC AND PNEUMATIC EQUIPMENT... CYLINDERS... VALVES

1751 Elston Avenue • Chicago 22, Illinois





Tomorrow's Electric Motors  
are available today . . . .

# COMPUTER

DESIGNED and PROVED

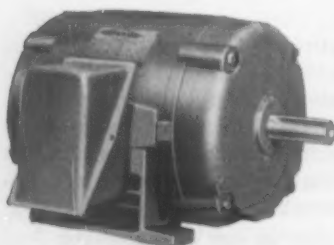
BEST POWER FOR THE STANDARD OR  
THE UNUSUAL MOTOR APPLICATION . .



Modern as the missile age . . . Imperial electric motors are created with a background of more than 70 years of industrial drive experience.

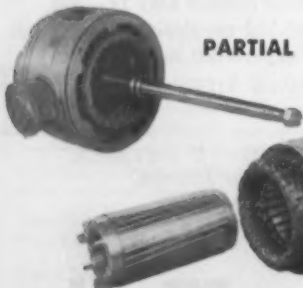
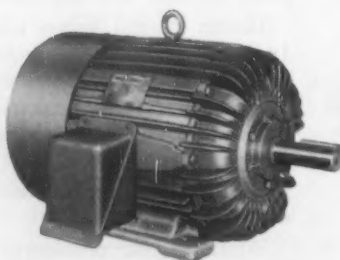
Now, through the use of electronic computers, multiple-design review is made possible in advance of production. Optimum performance is assured while delivery of special-purpose designs is speeded.

For standard NEMA motors and for motors to meet unusual drive requirements, you will do better with Imperial. Write for bulletin covering *The Imperial Line* of integral horsepower motors, generators and motor-generator sets for every application.



**DRIP-PROOF A-C MOTOR**—Today's Best Buy for Most Applications—Ratings from 1 to 200 Hp.—Designs Include Flange and Face Types, Multi-Speed, etc.

**TOTALLY-ENCLOSED, FAN-COOLED A-C MOTOR** Provides Dependable Operation Under Abnormal Conditions — Also Available in Explosion-Proof Design—1 to 100 Hp.



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**SHELL-TYPE SHAFTLESS MOTOR** . . . Other Special or Specific Types . . . Provide Maximum Power in Minimum Space . . . Blend with Basic Design of Machines.



**ELECTRIC COMPANY**

84 Ira Avenue • Akron 9, Ohio

## NEW PARTS AND MATERIALS



mounting styles, plus a clevis-mounted model which incorporates self-alignment spherical bearings at both pin connections. The 3 H series, for operation at 3000 psi, is very compact and is offered with a wide selection of rod sizes and cushion controls. **Pathon Mfg. Co.**, 3823 Pacific Ave., Cincinnati, Ohio.

Circle 728 on Page 19

## Solid-Film Lubricant

retains low  
coefficient of friction

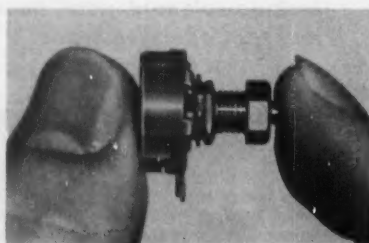
Surf-Kote A-1290 air-drying, solid-film lubricant containing molybdenum disulfide is conveniently applied by spraying, dipping, or brushing. It provides a hard, durable, solid-film lubricant on most types of metal surfaces. Lubricant retains a low coefficient of friction over a wide range of pressures, temperatures, and surface speeds, preventing galling, seizing, fretting corrosion, and cold welding. After drying, lubricant is not affected by humidity or unusual atmospheres and remains securely bonded to metal surfaces. **Hohman Plating & Mfg. Co.**, 814 Vermont Ave., Dayton, Ohio.

Circle 729 on Page 19

## Variable Resistor

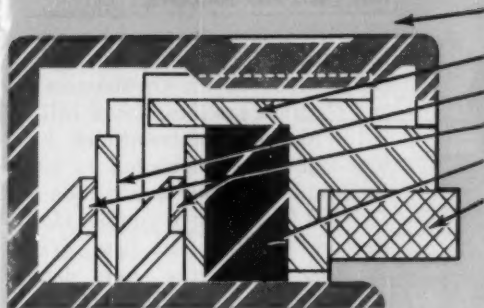
for high-temperature  
operation to 125 C

Small 1½-w, wirewound variable resistor, Model 3W, is one-third smaller than otherwise similar units.



MACHINE DESIGN

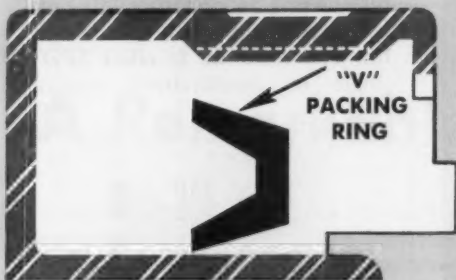
# GITS HH-TYPE SEAL SERIES



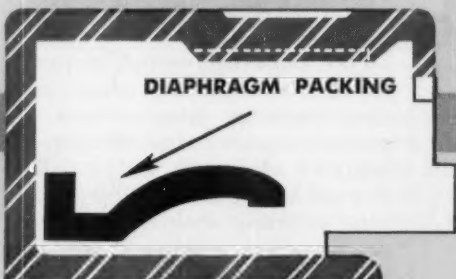
SHELL  
ADAPTER  
SEPARATOR  
SPRING  
FLAT PACKING RING  
SEAL RING



"O" RING PACKING



"V" PACKING RING



DIAPHRAGM PACKING



WEDGE PACKING RING

VITON "A"

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

Circle 528 on Page 19

# GITS

*Extra Flexibility For  
Your Seal Applications!*

## ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

Use of this one standard Gits HH-type seal envelope — with your choice of the five seal packing arrangements illustrated at left — permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements.

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information.

## GITS BROS. MFG. CO.

1868A South Kilbourn Avenue • Chicago 23, Illinois

**NEW!** Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.

# SOLVE DESIGN and MAINTENANCE PROBLEMS



SPECIFY  
**STRATOFLEX**  
HOSE AND FITTINGS

Stratoflex was specified for the precision hydraulic tracing control kit on this tool room milling machine.

When you design with Stratoflex you get more than the vibration and stress resistance inherent in flexible hose. You get hose fittings designed to meet your specific requirements. And with Stratoflex leak-proof reusable fittings you simplify maintenance by making possible quick, easy replacement or modification. You solve both design and maintenance problems when you specify Stratoflex.

Write for  
Bulletin  
S-2 today

SF10-9

**STRATOFLEX**  
Inc.

P.O. Box 10398 Fort Worth, Texas  
Branch Plants: Hawthorne, Cal., Fort Wayne, Toronto  
In Canada: Stratoflex of Canada, Inc.

SALES OFFICES:  
Atlanta, Chicago  
Cleveland, Dayton  
Detroit, Fort Wayne  
Fort Worth, Hawthorne  
Houston, Kansas City  
Milwaukee, New York  
Philadelphia  
Pittsburgh, San Diego,  
San Francisco, Seattle  
Toronto, Tulsa

## NEW PARTS AND MATERIALS

Designed for high-reliability applications, it meets the environmental and electrical specifications of MIL-R-19. Model is recommended for high-temperature operation to 125 C. Completely closed construction is designed for sealing or potting. Unit measures 11/16 in. in diam, 5/16 in. deep, and has a 1/8-in. diam stainless-steel shaft. Terminals are gold-plated stainless steel. Unit has a rating of 1 1/2 w at 40 C; resistance range is 4 to 30,000 ohms. Centralab Div., Globe-Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.

Circle 730 on Page 19

## Rotary Limit Switch

10-amp unit  
weighs less than 0.16 lb

No. 00-304 environment-free rotary limit switch, an aircraft-quality unit, has a 10-amp rating, yet weighs less than 0.16 lb. It offers SPDT single or double-circuit control,



DPDT four-circuit control, plus excellent installation and adjustment ease. Operating lever contains a micrometer screw for infinite operating-point adjustment, and a separate self-locking nut fixes operating point to insure repeatability. Panel or screw-type mounting, plus a variety of electrical connectors, add to the versatility of the switch. Licon Div., Illinois Tool Works, 6006 W. Dakin St., Chicago 34, Ill.

Circle 731 on Page 19

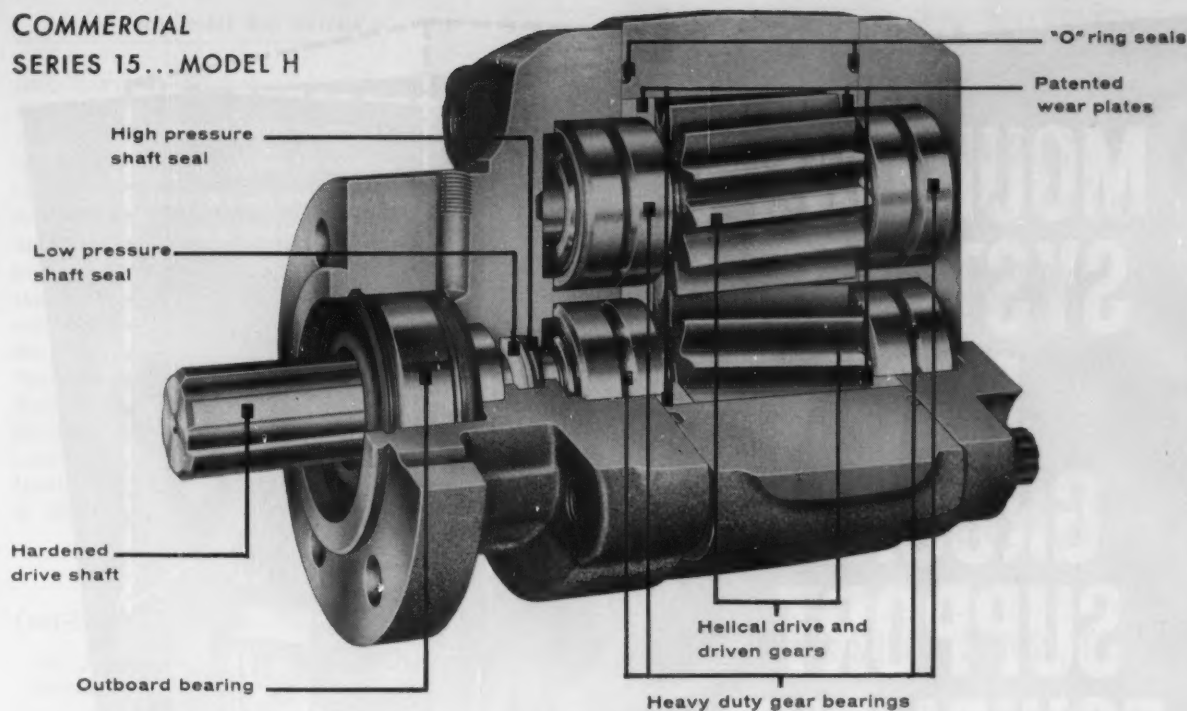
## Epoxy-Glass Laminate

for printed-circuit use

Flame-retardant, 155-C, epoxy-glass laminate for printed circuits has excellent electrical properties, moisture resistance, high strength, and good machinability. No. 6097 Lami-coid is available, under the name CuClad, with 1 or 2-oz copper foil bonded to one or both sides. Lami-



**COMMERCIAL  
SERIES 15...MODEL H**



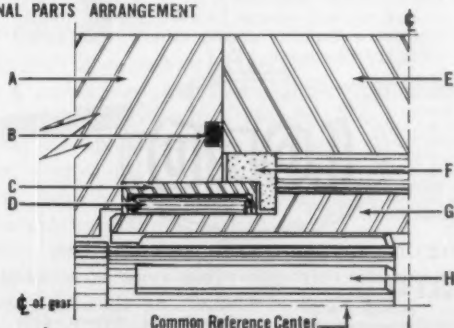
## A Remarkable New Fluid Power Pump

COMMERCIAL presents the new, Series 15H fluid power pump—a logical extension of its Series 36H line which has received such outstanding acceptance. This small powerhouse possesses all the proven basic features of the larger COMMERCIAL fixed displacement gear pump but is designed for those applications where flow requirements are less. The Series 15H is made in  $\frac{1}{2}$ ",  $\frac{3}{4}$ ", 1",  $1\frac{1}{4}$ ",  $1\frac{1}{2}$ ",  $1\frac{3}{4}$ " and 2" gear widths and covers a delivery range from 3 to 15 gpm at 1200 rpm. It is recommended for continuous duty operation at pressures up to 2000 psi—at speeds up to 2400 rpm. Volumetric and mechanical efficiency rate over 90%. 15H pumps are available for flange or pad mountings of many styles and can be furnished with ports to accept tapered thread, straight thread or SAE split flange fittings.

### High performance for keeps

Perfect alignment is "built in" these pumps because of

#### INTERNAL PARTS ARRANGEMENT



A-bearing carrier    B-"O" ring seal    C-bearing outer race    D-bearing roller  
E-gear housing    F-floating thrust plate    G-gear    H-drive shaft spline

their unique basic construction which establishes the machining of all parts from one common reference, the gear center line. (See drawing.)

As shown, gear bearings also act as dowels—outmoded dowel pins are eliminated.

Matched helical gears having mirror finish ground on all surfaces contribute to high volumetric efficiency and quiet operation. Thus, complete sealing is maintained—tooth to tooth and tooth to gear housing. Ruggedness, greater load capacity and dampening of unbalanced internal loading are assured by using integral gear hubs to serve as journals for the pump's oversize gear bearings. In order to meet its own exacting standards, COMMERCIAL must, and does, produce its own gears.

A dynamic seal is maintained between gear faces and special bronze alloy gear thrust plates. The entire thrust plate "closes in" against the gear face because of pressure pocketed behind the plate, thus compensating for any wear on its gear contact surface. Because the sealing area is confined to a small portion of the contact surface, the amount of friction has no appreciable effect on pump mechanical efficiency.

Engineering experience available—personal technical service and assistance is yours for the asking. For more information write to Commercial Shearing & Stamping Company, Dept. S-34, Youngstown 1, Ohio.

pumps, valves,  
cylinders, motors

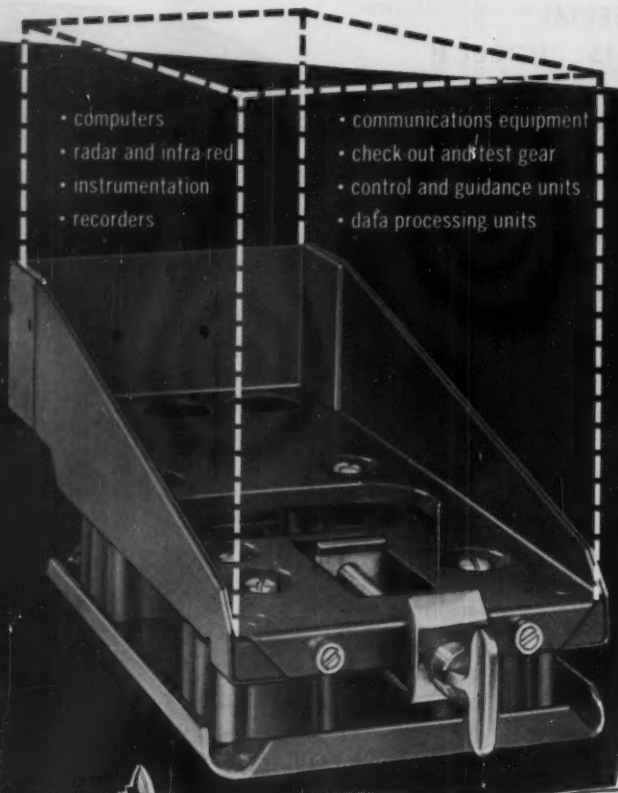
**COMMERCIAL**  
shearing & stamping



# MOUNTING SYSTEMS FOR GROUND SUPPORT EQUIPMENT

- computers
- radar and infra-red
- instrumentation
- recorders

- communications equipment
- check out and test gear
- control and guidance units
- data processing units



protect sensitive equipment against punishing environments

Engineers responsible for the reliability of ground support equipment will find LORD a highly qualified source for resilient mounting systems. Here's what LORD offers:

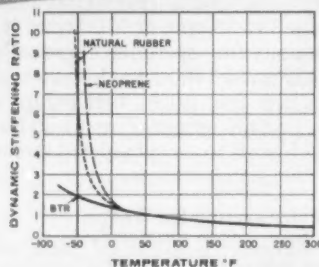
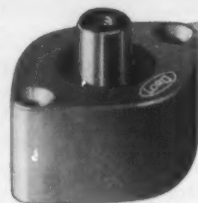
**Optimum performance**—assured by custom engineering on overall systems basis, and complete familiarity with vehicular environment.

**Advanced techniques**—resulting from unceasing research and LORD's 35-year background in vibration/shock/noise control.

**Economy**—made possible by proved designs, qualified components and extensive facilities for engineering, production and testing.

**Minimum design time**—capable field engineering personnel can be your "right arm" on vibration and shock problems. Close teamwork with your engineers moves your project to final design faster.

Contact your nearest Lord Field Engineering Office or the Home Office, Erie, Pennsylvania.



Low-temperature protection is a vital advantage offered by Lord mounting systems. Exclusive Lord BTR® Mountings retain flexibility despite extreme cold, control shock and vibration to -65° F.



## FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA - Cedar 7-9247  
 BOSTON, MASS. - Hancock 6-9135  
 CHICAGO, ILL. - Michigan 2-6010  
 DALLAS, TEXAS - Riverside 1-3392  
 DAYTON, OHIO - Baldwin 4-0351  
 DETROIT, MICH. - Diamond 1-4340  
 KANSAS CITY, MO. - Westport 1-0138

LOS ANGELES, CAL. - Hollywood 4-7593  
 NEW YORK, N. Y. (Paramus, N. J.)  
 New York City - Bryant 9-8042  
 Paramus, N. J. - Diamond 3-5333  
 PHILADELPHIA, PA. - Pennypacker 5-3559  
 SAN FRANCISCO, CAL. - Exbrook 7-6280  
 WINTER PARK, FLA. - Midway 7-5501

\* "In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

nate is readily fabricated by conventional techniques. The bond which joins electrolytically deposited copper foil to the laminate has high peel strength and is not affected by standard plating and etching solutions. Dip or float soldering may be used to make connections without damaging the laminate. Lamicaid meets and exceeds the requirements of military specification MIL-P-18177B, type GEB. Sheet is available in standard satin-finished 36 x 42-in. size, in thicknesses from 1/64 to 2 in. Mica Insulator Div., Minnesota Mining & Mfg. Co., Schenectady 1, N. Y.

Circle 732 on Page 19

### Cast-Iron Footswitch

for general-purpose industrial applications

Rugged footswitch has a cast-iron housing and baked black wrinkle



finish. It is precision-built and is easy to operate. Unit, available with guard, has a 15-amp rating. Two switches, one momentary and one maintained, are available. Vemaline Products Co., Franklin Lakes, N. J.

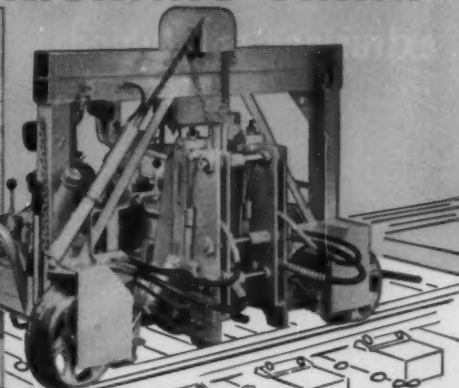
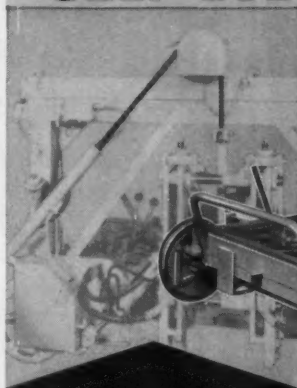
Circle 733 on Page 19

### Machine-Tool Motors

in additional  
15 and 20-hp sizes

Series 1400 machine-tool motors feature a newly designed frame and are available in two new ratings, 15 and 20 hp, in addition to the previous series of 1/2 through 10 hp. Motors have vibrationless running characteristics essential to precision machine-tool operation. Rotors are dynamically balanced and mounted between two heavy-duty ball bearings. Radial air-gap design with a light, thin, low-inertia rotor provides smooth-start, quick-stop operation.

## Another Tough Problem SOLVED BY WHITNEY MSL\* SELF-LUBRICATING CHAIN



### Resists SHOCK, STRESS, FATIGUE ON Railway Maintenance Machines

Raising and lowering a 550 lb. nipper assembly on the Racine Seco "Anchor-Fast" Rail Anchor Applicator approximately 18 times per minute puts severe shock, stress, and elongation loads on a chain.

Yet—the standard Whitney MSL Self-Lubricating Chain used on these hard-working track maintenance machines which apply rail anchors to the base of railroad rail to keep it from creeping lengthways, is providing superior performance month after month without a single instance of chain failure!

The chain replaced a steel cable which connected a hydraulic cylinder to the load. Through abuse in the field, the cable would develop kinks or twists that could not be removed, thus affecting the operation of the machine. Some excessive cable wear was experienced.

MSL Chain's built-in lubrication at the 3 critical wear areas provides great inherent strength and superior resistance to shock, stress, and fatigue. The chain remains flexible for life . . . does not bind or freeze . . . requires no maintenance, and provides up to 5 times longer service life than ordinary chain.

If the drive chain on your product must deliver optimum performance in severe operating environments, or operate with maximum cleanliness, check the advantages of Whitney MSL Self-Lubricating Chain. It is completely interchangeable with any similar pitch ASA standard chain. Write for MSL Chain Catalog today.

\*MAXIMUM SERVICE LIFE

### Built-in Lubrication at these 3 Critical Areas

#### Critical Area 1:

**PIN**—Protective oil film lubricates live bearing area between pin and bushing, minimizing wear by reducing metal-to-metal contact.

#### Critical Area 2:

**PLATES**—Oil-impregnated Sintered Steel Bushings extend beyond surface of inside plates to: act as lubricated thrust bearings, control clearance, and provide an oil cushion between plates, eliminating plate galling and seizing frequently caused by misalignment of sprockets.

#### Critical Area 3:

**SPROCKET ENGAGEMENT**—Oil film on MSL Bushing exterior provides constant lubrication between sprocket teeth and chain. Whitney MSL Chain requires no rollers, as the tough oil film on the bushing surface provides smooth sprocket engagement, cushions impact and reduces drive wear.

**THE WHITNEY**

a subsidiary of FOOTE BROS.  
GEAR AND MACHINE CORPORATION

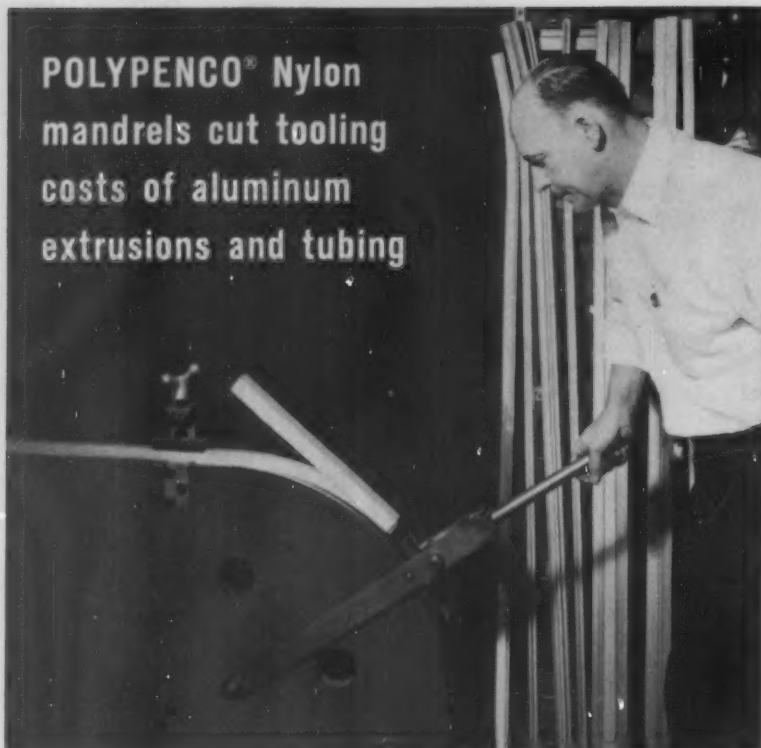


**CHAIN COMPANY**

4567 S. Western Blvd., Chicago 9, Ill.

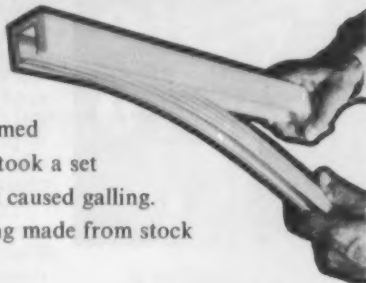
**POWER TRANSMISSION DRIVES**

## POLYPENCO® Nylon mandrels cut tooling costs of aluminum extrusions and tubing



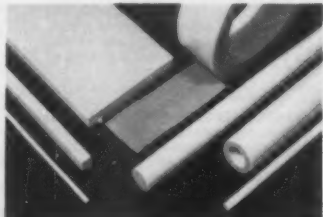
Economical POLYPENCO Nylon Stock Shapes replaced steel and bronze mandrels in the production of aluminum awnings . . . at considerable savings.

Each custom-made awning required four separate 17-inch radius bends, pre-formed at the factory or formed in the field. Steel mandrels eventually took a set while bronze picked up aluminum and caused galling. Both problems were solved with tooling made from stock shapes of POLYPENCO Nylon 101.



To solve your tooling problems—consider tough, wear resistant nylon, the industrial plastic which will not gall or scratch mating surfaces. Low surface friction without lubrication, resilience and ease of fabrication are added property premiums to give you longer part life, improved quality and lower costs.

POLYPENCO Nylon Stock Shapes (600 sizes in more than 14 nylon formulations) are available from stock in all major cities. For details or technical help call your nearby Polymer representative.

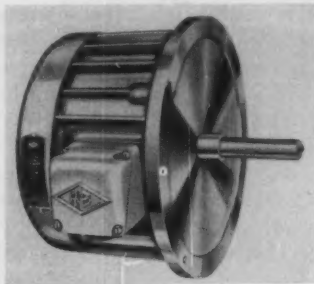


INDUSTRIAL PLASTICS

The Polymer Corporation of Penna.  
Reading, Pa.

Circle 533 on Page 19

## NEW PARTS AND MATERIALS



Close tolerances are maintained throughout manufacture. Reuland Electric Co., 3001 W. Mission Rd., Alhambra, Calif.

Circle 734 on Page 19

## Wire Insulation

of reinforced Teflon  
resists abrasion

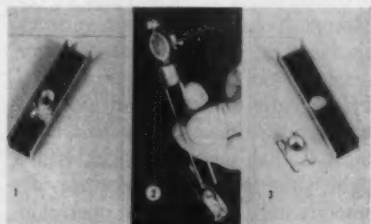
Type AR wire insulation offers excellent resistance to abrasion, plastic flow, cut-through, and heat. Process consists of adding mineral-fiber particles to Teflon, particles averaging about 1 micron in diam and 500 to 1000 microns long. Improved resistance to abrasion and cut-through is the result of orienting more than 90 per cent of the fibers parallel to the wire surface. The all-Teflon insulation has uniform dielectric properties. Mechanical properties remain satisfactory for many hours at temperatures of 325 to 400 C. W. L. Gore & Associates Inc., 487 Paper Mill Rd., Newark, Del.

Circle 735 on Page 19

## Gang Channel

for high-temperature use

Tap-out gang channel is for use on jet engines and other high-temperature applications. Extended life of lock nuts in the channel permits greater reusability than previously. Lock nuts can be removed easily, without special tools, where installa-



MACHINE DESIGN



# new DIAMOND TUF-FLEX<sup>®</sup> ROLLER CHAIN

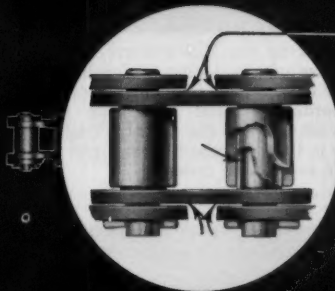
The Roller Chain that can take more because it's built to give more!

DIAMOND *Tuf-Flex* is a rugged new *straight link* power transmission chain—especially engineered to provide extra durability and unusual flexibility to meet the strenuous service demands of heavy construction machinery. It is especially suited for equipment such as concrete transit-mix trucks and all types of power excavating shovels.

Proven advantages of *Tuf-Flex* are:

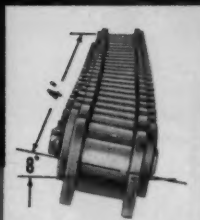
- Longer service life
- Higher working load capacity
- Will accept greater misalignment of sprockets
- Greater capacity for shock and peak loads
- Easier chain connection
- May be used on existing sprockets of the same pitch

\*The trademark *Tuf-Flex* is the property of Diamond Chain Company, Inc.



Greater clearance between inside and outside linkplates, and between pins and bushings, permit extra flexibility and reduce stiffness after periods of idleness or exposure.

Up to 4" lateral displacement from center line per 4' of chain (above), and up to 8° of twist (right) accommodate sprocket misalignment due to twisting of machine's frame.



*Tuf-Flex* straight linkplates transmit loads in a straight line, utilizing maximum load capacity of linkplates, pins and bushings.

American Standard Dimensional Specifications permit DIAMOND *Tuf-Flex* to operate over existing sprockets cut for American standard roller chains of the same pitch, or equivalent offset side-bar chains.

DIAMOND *Tuf-Flex*  
meets Military  
and ASA Specifications; write for  
Dimensional Data  
and Prices



Write today for new *Tuf-Flex* Bulletin No. 2600. Gives engineering features, construction details, specifications and prices.

**DIAMOND CHAIN COMPANY, INC.**

*A Subsidiary of American Steel Foundries*

Dept 435, 402 Kentucky Ave., Indianapolis 7, Ind.  
Offices and Distributors in All Principal Cities

**DIAMOND**

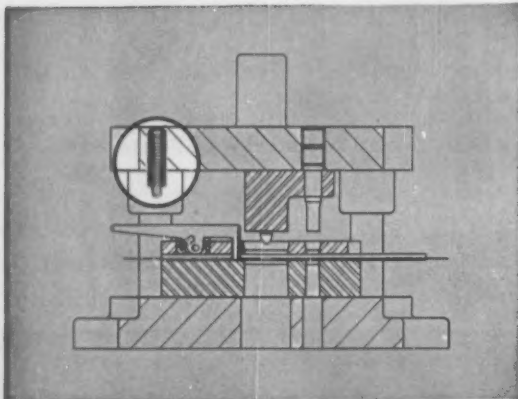


**ROLLER  
CHAINS<sup>®</sup>**



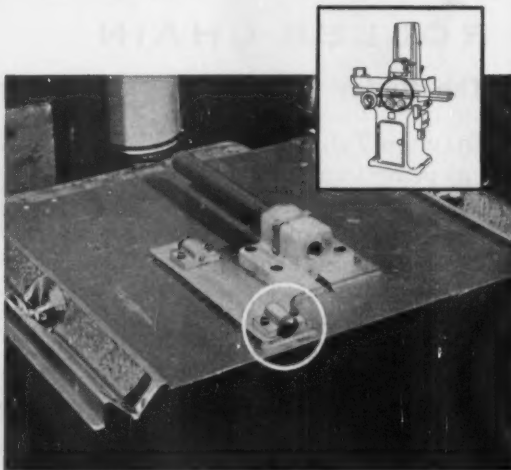
# Practical Design Tips

Number 2 of a series.

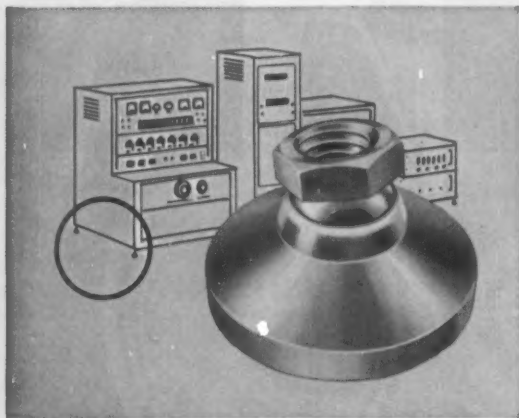


**TO STOP SMASHING DIE STOPS**, substitute a Vlier Spring Plunger for the usual square-head screw. The plunger actuates the automatic stop perfectly and, unlike the screw, never needs adjusting no matter how many times the die is resharpened. Available in four models: 50 sizes.

Substituting simple, off-the-shelf Vlier Tooling Accessories for complicated, custom-made devices in both tooling and original equipment applications can result in important savings. Why not put them to work in your plant?



**TO CUSHION SHOCK** as the bed traverses, this surface grinder manufacturer uses two Vlier Spring Stops, reducing wear and tear on the machine. These clever, spring-loaded devices, ordinarily used on fixtures where the absence of side walls prevents the use of spring plungers, are now available in three standard sizes: 3 end pressures. Special sizes made to quantity orders.



**TO LEVEL MACHINE TOOLS**, electronic racks, benches, etc., use the standard Vlier leveling pad. The pad swivels to  $7\frac{1}{2}^\circ$  each side of the center line; adjusts automatically to uneven surfaces. Unique ball-joint design distributes weight over entire pad surface.



**TO GET NEW IDEAS** on how to save with Vlier Tooling Accessories, send for new 28-page booklet "Typical Applications of Vlier Tooling Accessories." It suggests dozens of ways to use these time-savers in both tooling and original equipment applications. Write for your copy today.

New catalog now ready!  
Send for your copy today.



Insist on Vlier Tooling Accessories...  
there's still no substitute for quality!

**VLIER ENGINEERING CORPORATION**

A subsidiary of Barry Controls, Inc.  
8900 Santa Monica Blvd. • Los Angeles 46, California

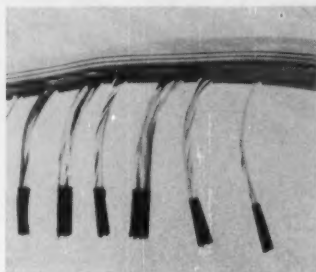
tion damage makes inspection or replacement necessary. Channel is available in straight and radius-channel types. Kaylock Div., Kaynar Mfg. Co. Inc., Box 2001 Terminal Annex, Los Angeles 54, Calif.

Circle 736 on Page 19

### Zippered Tubing

is tapered to  
provide tight fit

New tapered Zippertubing offers a tight-fitting cable jacket for cables of decreasing diameters due to branch-outs. Wires can be pulled through perforations of the tubing



to permit attachment to termination points. Tapered tubing is supplied according to specifications and is available in colors matching all types of cable jackets. Zippertubing Co., 752 S. San Pedro St., Los Angeles 14, Calif.

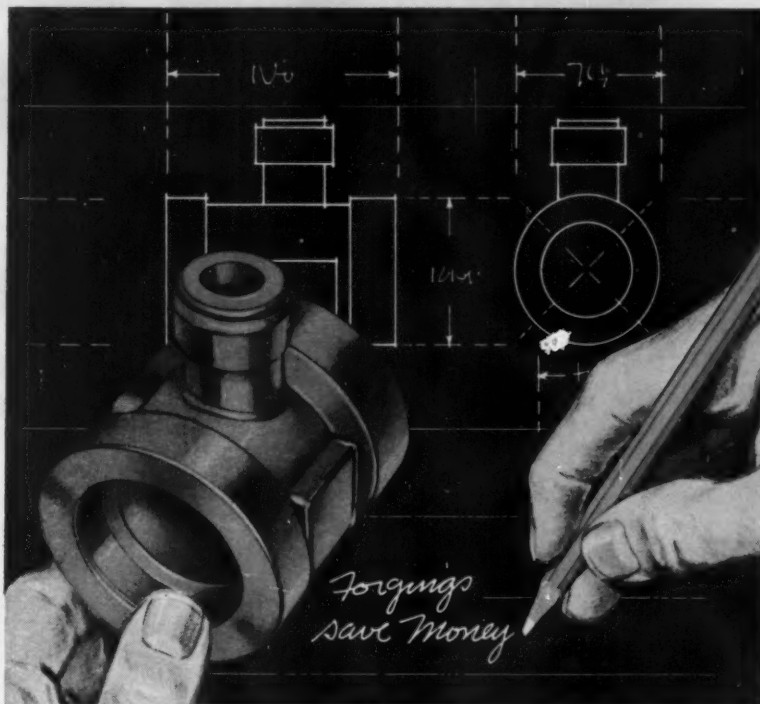
Circle 737 on Page 19

### Copper Alloy

has high tension strength  
and resistance to corrosion

Cunisil 837 is 97.50 per cent copper, 1.90 per cent nickel, and 0.60 per cent silicon. The high-strength, corrosion-resistant alloy is intended for uses where this combination of physical, mechanical, and fabrication properties is needed, such as in electrical equipment. Alloy has high tensile strength, high yield strength, high electrical conductivity, and excellent cold-forming characteristics before hardening heat treatment. Compared with free-cutting brass rod rated at 100, its machinability rating is approximately 40. Precipitation of nickel silicide in the form of particles of sub-microscopic size by a relatively low-temperature heat treatment ac-

## DESIGN YOUR PART AS A BRIDGEPORT CORED FORGING SAVE MATERIAL... SAVE LABOR



You can design efficiency and savings into your product with Bridgeport Cored Forgings.


For example, by switching from a solid forging to a cored forging in the production of a fire-extinguisher discharge head, a 20% saving in labor and a 45% saving in metal were realized by one manufacturer. The cored forged part weighed only 2½ lbs. versus 4½ lbs. for the solid brass forging. This weight advantage, along with lower machining costs when new combination tools were used, was achieved with just one stroke of the forging press!

Bridgeport Cored Forgings give your metals components qualities unequalled by any other metal-forming method. They can reduce machining and finishing, lower metal requirements and tool costs.

Stronger parts and components without flaws can be designed to eliminate assembly operations. All these design advantages bring new efficiency to your part and production methods.

A book on the subject, "Bridgeport Forgings," is yours for the asking. Write Dept. 8908.



CORED FORGING DIVISION  
**BRIDGEPORT BRASS COMPANY**   
1000 Connecticut Ave., So. Norwalk, Conn.  
Specialists in Metals from Aluminum to Zirconium



## 1001 ACCESSORIES TO INSURE HIGHEST AIR CIRCUITRY PERFORMANCE

*Select from full lines to operate and control a single OEM product  
... or a plant's entire production line!*

Air circuits perform no better than each component. In addition to quality air cylinders and valves, you need accessories of proven reliability. Schrader has them in full lines to make compact, rugged air systems that will install easily, perform tirelessly. See your Schrader distributor who has everything you need, plus factory-trained experts to give you ideas and assistance.



The complete range of sizes and types of air circuitry products is stocked and cataloged by your Schrader distributor. Consult the yellow pages or write Schrader.

**Schrader**  
a division of **SCOVILL**

A. SCHRADER'S SON  
Division of Scovill Manufacturing Company, Incorporated  
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS



counts largely for the distinctive properties of the alloy. Alloy is available in round rod, with or without final precipitation-hardening heat treatment, in straight lengths from 3/16 to 1-in. diam, and in coils from 3/16 to 5/8-in. diam. American Brass Co., Waterbury 20, Conn.

Circle 738 on Page 19

### Switch-Light

switches low currents  
from 1/4 to 500 mils

Panel-mounted, switch-light combination for switching low currents from 1/4 to 500 mils can be supplied in SPST or SPDT, double break, positive action, either with momentary contacts or push-on, push-off



mechanism. Plunger can be made to remain in, which would require pressing again to release. Plunger is light action, operating at below 1 lb pressure if desired. Pushbuttons have a snap-in feature for rebulbing from front of panel. Any size, shape, or color lens can be supplied. Switch Div., Pendar Inc., 14744 Arminta St., Van Nuys, Calif.

Circle 739 on Page 19

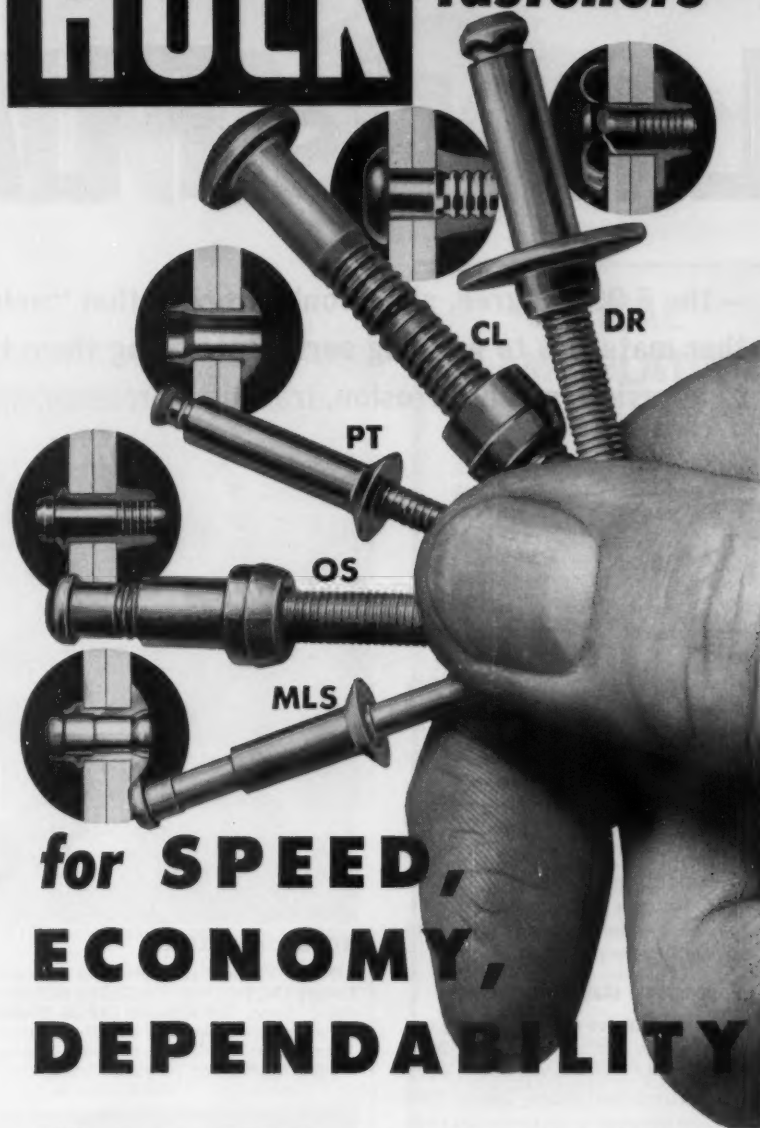
### Cable Clamps

are molded of polypropylene

New cable clamps molded of polypropylene have heat resistance approaching that of nylon, have good chemical resistance, and are virtually unbreakable. Injection molding eliminates built-in stresses that often lead to fractures in the field. Absence of cold flow at elevated

(Please turn to Page 236)

# HUCK fasteners



**for SPEED,  
ECONOMY,  
DEPENDABILITY**

HUCK gives you MORE than "just a fastener". Huck's foolproof installation tools, convenient power units and versatile fasteners give you uniformity and speed of installation beyond your fondest hopes, even with inexperienced operators. Savings of up to seventy per cent on installed cost have been obtained by many users of Huck fasteners.

There is a HUCK fastener to meet your specific requirements whether they be high tensile or shear strength, blind application, thin sheets, wood-to-metal, broad bearing area, flush installation, high clinch, positive mechanical lock, elevated temperature, corrosion resistance or speed of application. A phone call can save you important production dollars. It costs you nothing to find out.

We invite your inquiries.

**HUCK** MANUFACTURING COMPANY

2480 Bellevue Avenue • Detroit 7, Michigan • Phone WA 3-4500



# UP TO 40 TIMES LONGER WEAR LINDE's FLAME-

—the 6,000-degree, supersonic process that “welds” tungsten carbide and other materials to working surfaces—giving them today's greatest resistance to abrasion, galling, erosion, fretting, corrosion, and high-temperature wear

LONGER service life . . . less down time . . . fewer rejects . . . reduced operating costs!

These are only a few of the important advantages that LINDE's Flame-Plating process builds into machines, parts, accessories, and products that depend on the stamina of metal surfaces for required performance. Exclusive Flame-Plating guns literally “blast” molten particles of tungsten carbide or aluminum oxide at specific areas—at 2,500 fps—depositing a hard, welded-on coating which can be precision-finished to the desired microinches rms.

## Dimensional stability unchanged

While temperatures above 6,000°F are reached within the oxy-acetylene detonation gun, the temperature of the work piece is maintained below 250°F. This eliminates warpage or distortion of even minute precision parts.

Depending on thickness of finish applied, or use of the wearing part, Flame-Plating has been known to multiply wear resistance more than 40 times.

## Hundreds of potential applications

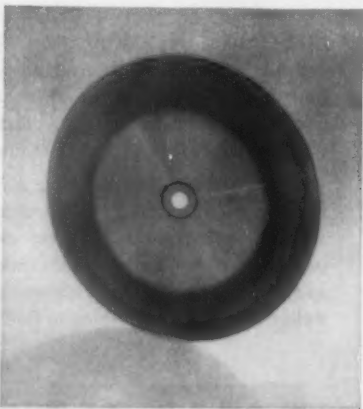
Other properties include low coefficient of friction, porosity less than one per cent, and excellent corrosion resistance. Coatings show outstanding reliability under high temperature, heavy load, and lack of lubrication or cooling.

The list on the right-hand page (opposite) shows a few of the many current and possible applications for Flame-Plating. Perhaps the process could be used profitably in one or more of your operations. We suggest you indicate your possible applications on the coupon and mail today for more information.



## ROBESON CUTLERY

LINDE's Flame-Plating provides Robeson Cutlery Co., Inc., with a distinctive merchandising theme. The Robeson line of “Flame Edge” cutlery is featured as “The Greatest Development in 2000 years of Cutlery Making—a Cutting Edge of Tungsten Carbide.”



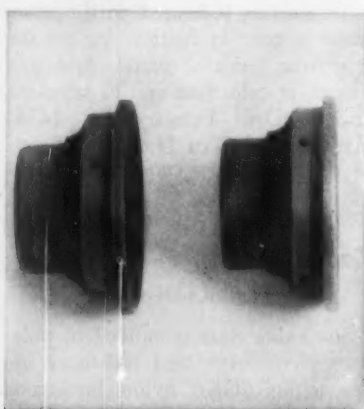
## RUBBER SKIVING KNIVES

Before Flame-Plating, skiving knives used in the rubber industry had to be sharpened after every shift. Since adoption of Flame-Plating the service life of this tool has been increased 15 times. A sharp edge is always present, due to a self-sharpening effect.



## LAWSON PAPER DRILLS

Paper manufacturers report increases in drill life up to 20 times with Lawson Company Flame-Plated tips. Less “puckering” delivers better quality; fewer stops for sharpening bring savings which outweigh the extra cost of Flame-Plating many times over.



## SEAMING CHUCKS

LINDE's Flame-Plating is an important time- and money-saver for the abrasive-resistant, tolerance-stable seaming chucks used by major canners. Operating life is more than 4 times longer. Chucks, when worn, can be salvaged, replated, and returned to use.

# for Metal Parts — Metal-Coated by PLATING



## THE "LINDE" FLAME-PLATING GUN—and how it works

In LINDE's revolutionary Flame-Plating process, precise quantities of oxygen, acetylene, and tungsten carbide powder—representing "powder and shot"—are fed into the gun by a special mechanism. The gun is aimed at the areas to be coated, then fired by remote control. Precision-controlled rapid-firing (4 per second) builds up the coating to the desired thickness. The as-coated smoothness of 125 microinches rms can be finished down to better than 1 microinch rms finish.

### PHYSICAL DATA—FLAME-PLATED COATINGS

COATING DESIGNATION	LW-1	LW-1N	LW-5	LC-1A	LA-2
Approx. Composition by weight	Tungsten Carbide + 6% to 8% Co	Tungsten Carbide + 13% to 16% Co	25% WC + 7% Ni + mixed W-Cr Carbides	85% Cr <sub>3</sub> C <sub>2</sub> + 15% Ni-Cr	99% + Al <sub>2</sub> O <sub>3</sub> (gamma)
Hardness Vicker's (VPN <sub>100</sub> )	1200 to 1450	1050 to 1150 VPN 70 to 71 R.	1000 to 1200 VPN	850 VPN	1000 to 1200 VPN
Maximum temp. in oxidizing atmosphere	1000°F.	1000°F.	1400°F.	1800°F.	1200°F. to 1800°F.
Coefficient of thermal expansion	4.0 x 10 <sup>-6</sup> /°F. Avg. 70 to 1000°F.	4.7 x 10 <sup>-6</sup> /°F. Avg. 70 to 1000°F.	4.6 x 10 <sup>-6</sup> /°F. Avg. 70 to 1400°F.	6.4 x 10 <sup>-6</sup> /°F. Avg. 70 to 1800°F.	3.9 x 10 <sup>-6</sup> /°F. Avg. 70 to 1832°F.
Modulus of Rupture	67,000 psi	80,000 to 106,000 psi	40,000 psi	75,000 psi	22,000 psi
Modulus of Elasticity	44 x 10 <sup>6</sup> psi	42 to 40 x 10 <sup>6</sup> psi	17 x 10 <sup>6</sup> psi	22 x 10 <sup>6</sup> psi	16 x 10 <sup>6</sup> psi
Porosity	0.5%	0.5 to 1.0%	0.5%	0.5%	1.0%
Specific Gravity	14.2	13.2	10.1	6.54	3.45
Specific Heat	0.048	0.056	0.070	0.127	0.196
Thermal Conductivity	5.3 at 500°F.	5.3 at 500°F.	3.8 at 500°F.	4.3 at 500°F.	0.86 at 500°F.
Main features	Extreme wear resistance	Excellent wear resistance + increased resist. to mechanical and thermal shock.	Excellent wear resist. to higher temps. improved corrosion resist.	Good wear resist. at high temp. or in corrosive media. Resists flame impingement.	Excellent resist. to wear, chem. attack and high temperature deterioration.

## LINDE COMPANY

Division of Union Carbide Corporation  
LINDE and UNION CARBIDE  
are trade-marks of Union Carbide Corporation.

## UNION CARBIDE

## TYPICAL FLAME-PLATING APPLICATIONS

**BEARINGS** — sleeve, roller, gas  
**BLADES** — aircraft turbine; doctor blades for papermaking  
**BLOCKS** — anvil  
**BUSHINGS** — ball piston pump  
**CHUCKS** — seaming  
**CUTLERY** — household  
**CUTTING, INDUSTRIAL** — rubber, plastic, skiving knives, foods, paper, slitter knives, chipper knives, discontinuous chip-abrasive materials  
**DIES, TOOLING** — cold-forming; coring punches, core rods, sizing punches, capstans  
**DOGS** — sewing machine feed; gripping dogs  
**DRILLS** — paper, acoustical tile, twist  
**GAGES** — plug, ring, air  
**GUIDES** — wire, textile, machine  
**HYDRAULICS** — pistons, liners, valve plates, wobble plates, metering valves, servo valves, slippers  
**MANDRELS** — wire-forming  
**PARTS** — sintered  
**PISTON RINGS**  
**PLATES** — valve, wear  
**SEALS** — turbine engine, pump  
**SURGICAL** — needle holders and shears  
**VALVES** — aircraft

MD818

Linde Company, Flame-Plating  
270 Park Avenue  
New York 17, New York

I am interested in Flame-Plating for the following application(s):

NAME \_\_\_\_\_ TITLE \_\_\_\_\_  
COMPANY \_\_\_\_\_  
ADDRESS \_\_\_\_\_  
CITY \_\_\_\_\_ ZONE \_\_\_\_\_ STATE \_\_\_\_\_

## UNIFORM Fine Seamless TUBING



● Write for your copy of Uniform Tubes' new catalog which describes fine seamless tubing in sizes down to .005" O.D., made from a broad range of ferrous and non-ferrous metals and alloys; their properties and applications.

Featured are seven different alloys of aluminum including Uniform Tubes' exclusive high-strength UT58 alloy; aluminum alloy instrument pointer tubing; copper alloys, including Beryllium Copper (Beryleo 25); precious metals; glass-to-metal sealing alloys; nickel and nickel alloys; the stainless steels, etc.

Also featured is Uniform Tubes' complete fabrication service for production of precision tubular parts to specification. (Several cost-cutting examples are pictured and described, to illustrate the broad capabilities of U.T. facilities and "know-how.")

Ask for Bulletin 60.



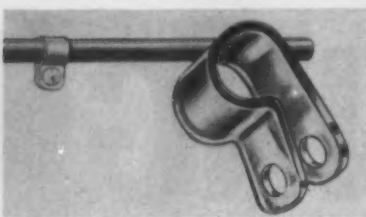
**UNIFORM TUBES,  
INC.** COLLEGEVILLE 2, PA.

HUxley 9-7276, TWX-CGVL 1044

Circle 540 on Page 19

## NEW PARTS AND MATERIALS

(Continued from Page 233)



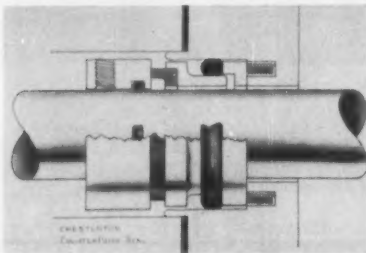
temperatures and the lightness of weight are important features. Sizes from  $\frac{1}{8}$  to  $\frac{1}{2}$  in. are available from stock. Commercial Plastics Co., 945 George St., Chicago 14, Ill.

Circle 740 on Page 19

### Mechanical Seal

uses balanced fluid pressure to close sealing faces

CounterPoise, a simple, reliable seal, gives positive, durable sealing by using balanced fluid pressure to replace operational springs. Springs are employed only to keep deep carbon faces in contact when pump



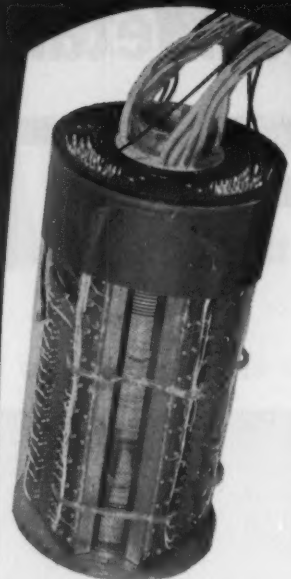
shutdown or pressure is reduced below operational level. Use of hydraulic pressure eliminates need for spring closing, and excessive and uneven face wear is eliminated. Conventional complex rotary mass is replaced by a single ring, cutting down excessive stuffing box turbulence. One standard seal design is used for all pressures. A. W. Chesterton Co., 6 Ashland St., Everett 49, Mass.

Circle 741 on Page 19

### Glass-Fiber Cloth

for use as electrical insulating material

Acto-Glas Mark II impregnated woven glass-fiber cloth has high physical strength in relation to its weight, excellent dimensional stability and tensile strength, low elongation and



### NEW SERIES of Antenna SLIP RING Assemblies

12 to  
500 RINGS

A standardized line of large Slip Ring assemblies, designed for a multiplicity of instrumentation, control and power circuit applications. First production assemblies are in use on radio telescopes, radar and tracking antennas and human centrifuge installations.

Assemblies vary from 12" to 72" in length, are either shaft or flange ball-bearing mounted and may be specified with hermetically sealed housings. Noise levels are held to a minimum. So are intercircuit losses, cross-talk and radiation, through proper shielding.

For complete information, write:



**SLIP RING COMPANY  
of AMERICA**

3612 West Jefferson Blvd., Los Angeles 16, Calif.

Circle 541 on Page 19



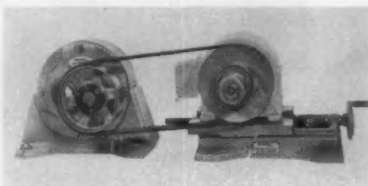
good dielectric properties, coupled with high resistance to solvents and chemicals. Product is designed to replace varnish-impregnated cotton tapes in electrical insulation. Cloth is supplied in the partially cured stage, and when subjected to heat, pressure, and time cycles, it becomes a fully cured homogeneous material in the nature of a laminate. Fully cured, tape offers a hard, smooth, nonrusting, corrosion-resistant finish. Impregnated cloth is being produced with a B-stage polyester resin Mark III or with an epoxy resin. Thicknesses range from 5 to 15 mils, and standard roll width is 38 in. Electro-Technical Products Div., Sun Chemical Corp., Nutley, N. J.

Circle 742 on Page 19

### Adjustable-Speed Drive

for use with  $\frac{3}{4}$ , 1,  $1\frac{1}{2}$ , 2, and 3-hp motors

Optimount variable-speed Reductor drive combines standard adjustable-speed pulley, belt, and adjustable motor base with a standard shaft-mounted or horizontal base-



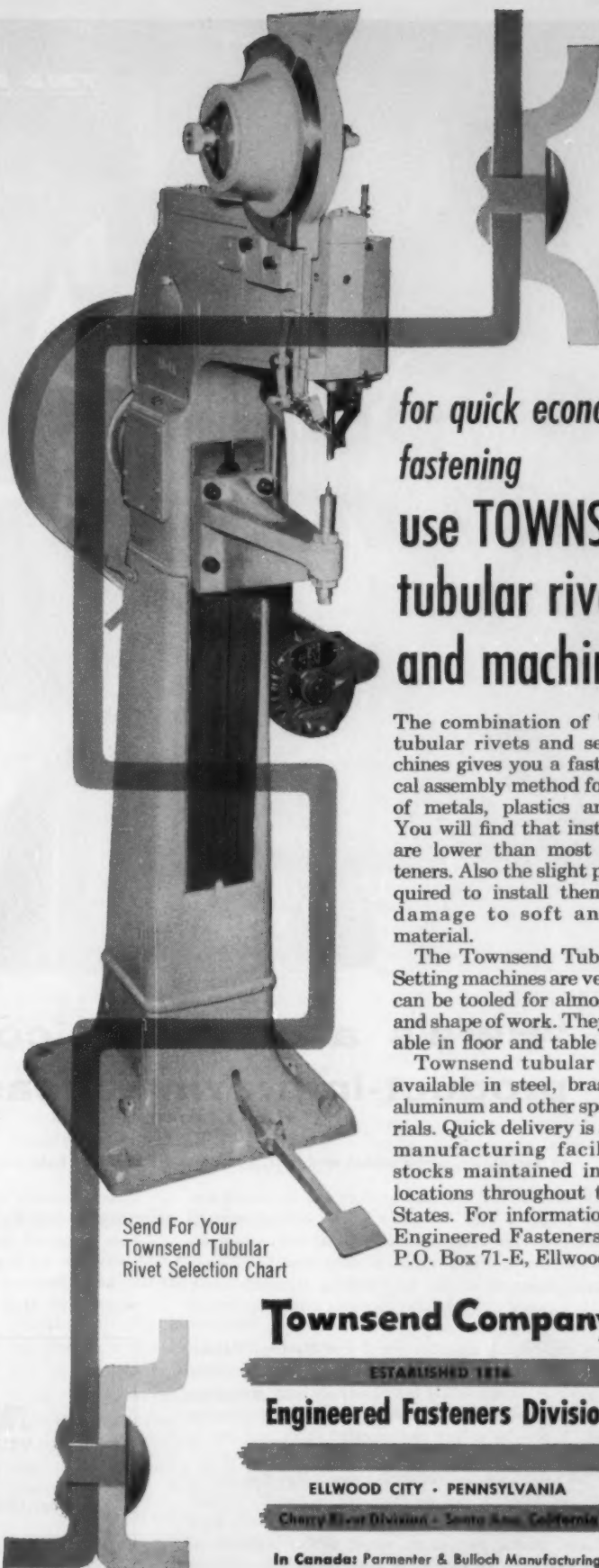
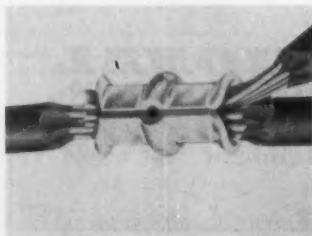
mounted, helical-gear speed reducer. It is designed for use with  $\frac{3}{4}$ , 1,  $1\frac{1}{2}$ , 2, and 3-hp motors. Driven shaft speeds are provided in various 3:1 infinitely-variable speed ranges between 431 and 24 rpm. Boston Gear Works, Quincy 71, Mass.

Circle 743 on Page 19

### Compression Taps

are color-keyed

Color-Keyed C-Tap is a simple, one-piece construction designed to give



for quick economical  
fastening  
use TOWNSEND  
tubular rivets  
and machines

The combination of Townsend tubular rivets and setting machines gives you a fast, economical assembly method for a variety of metals, plastics and fabrics. You will find that installed costs are lower than most other fasteners. Also the slight pressure required to install them prevents damage to soft and fragile material.

The Townsend Tubular Rivet Setting machines are versatile and can be tooled for almost any size and shape of work. They are available in floor and table models.

Townsend tubular rivets are available in steel, brass, copper, aluminum and other special materials. Quick delivery is assured by manufacturing facilities and stocks maintained in strategic locations throughout the United States. For information write to Engineered Fasteners Division, P.O. Box 71-E, Ellwood City, Pa.

Send For Your  
Townsend Tubular  
Rivet Selection Chart

## Townsend Company

ESTABLISHED 1874

### Engineered Fasteners Division

ELLWOOD CITY • PENNSYLVANIA

Cherry River Division • Santa Ana, California

In Canada: Parmenter & Bulloch Manufacturing  
Company, Limited, Gananoque, Ontario





## "Here's a boxful of cost-cutting, product-improving ideas for you"

**In versatility, performance and cost, Vulcanized Fibre may help crack your next design problem**

For proof, look at this National product and its almost unbelievable range of uses. To name a few: delicate surgical instruments; rail joint insulation for railroads; clothes hampers for the home; dense, durable gears and cams; flexible backings for abrasive disks; arc chutes for lightning arrestors; motor insulation; punched tape for data processing machines; formed athletic guard equipment.

Among engineering materials you'll find National Vulcanized Fibre unique and surprisingly economical. It weighs only half as much as aluminum. It has unsurpassed arc resistance, low thermal conductivity, excellent resilience and high abrasion resistance. It absorbs sudden and repeated shock and impact without failure. And it is available in a fire resistant grade.

After 100 years, users are still finding new things they can do *to* Vulcanized Fibre. It can be machined, polished, painted, embossed, lacquered and combined with other materials, such as laminated plastic, aluminum, wood, rubber, asbestos or copper. It can even be formed or deep drawn into intricate

shapes. Available in both standard and special forms and sizes.

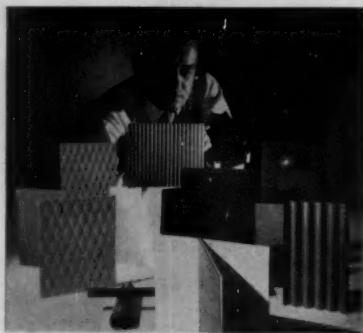
Send for our special kit of samples (shown above)—write on your letterhead please—and evaluate the design possibilities personally. Let us know what use you have in mind. We'd like to help. National Vulcanized Fibre Co., Dept. G-8, Wilmington 99, Delaware.



**NATIONAL**  
**VULCANIZED FIBRE CO.**  
WILMINGTON 99, DELAWARE

*In Canada:*

NATIONAL FIBRE CO. OF CANADA, LTD., Toronto 3, Ontario



## CHOOSE FROM THESE MATERIALS...

**Vulcanized Fibre:** 10 standard grades; many special grades.

**PHENOLITE® Laminated Plastic:** over 80 standard and modified grades; paper, cotton fabric, nylon, asbestos, glass fabric, cotton and glass mat bases; phenolic, melamine, polyester, epoxy, teflon or silicone resins.

**PEERLESS Electrical Insulation:** coil, strip, corrugated.

**Extruded Nylon:** 2 grades; rod, strip, pressure tubing, special shapes.

**Polyester Glass Mat:** 4 standard sheet grades; custom molded shapes.

**PHENOLITE Copper-Clad Laminates:** 10 standard grades.

**Combination Materials:** Rubber-PHENOLITE; Rubber-Fibre; Wood-Fibre; Metal-Fibre; Asbestos-Fibre; PEERLESS-PHENOLITE.

## BACKED BY THESE SERVICES...

Field Application Assistance  
Complete Fabricated Parts Service  
Stock Program for Immediate Shipment

## BY CALLING THESE OFFICES...

Baltimore	Valley	3-0393
Boston	TWinbrook	4-3500
Chicago	AUstin	7-1935
Cincinnati	GAirfield	1-0632
Cleveland	ERiewick	1-0240
Dallas	DAvis	4-4386
Denver	MAin	3-2077
Detroit	UNiversity	3-3632
Griffin, Ga.		8-1308
Indianapolis	WAlnut	3-6381
Los Angeles	RAymond	3-0291
Milwaukee	BRoadway	6-6995
New Haven	LOcust	2-3594
Newark	MIitchell	2-6090
New York	COrtlandt	7-3895
Philadelphia	SHerwood	8-0760
Pittsburgh	FAirfax	1-3939
Rochester	HIllside	5-0900
St. Louis	PArkview	5-9577
St. Petersburg		5-5505
San Francisco	DAvenport	6-4667
Seattle	MElrose	2-7298
Wilmington	OLympia	5-6371

### IN CANADA:

National Fibre Co. of Canada, Ltd.  
Toronto LENnox 2-3303  
Montreal AVenue 8-7536



**NATIONAL**  
VULCANIZED FIBRE CO.

WILMINGTON 99, DELAWARE  
In Canada:  
NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario

## NEW PARTS AND MATERIALS

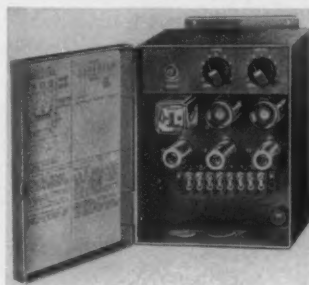
lowest installed cost. Nine C-Tap sizes will tap any two code copper conductors from two No. 10 to two No. 1/0 and any combination of large main to smaller branch from No. 10 to 3/0. All around compression of the C-Tap assures a tensile strength exceeding UL requirements. Thomas & Betts Co., 36 Butler St., Elizabeth 1, N. J.

Circle 744 on Page 19

## Electronic Counter

batches in quantities  
up to 100

Fully-electronic predetermining counter, Tally-Count 242, features high speeds, no moving parts to wear, and instantaneous reset to zero at the completion of each



batch. Unit will batch in quantities to 100. Industrial applications include batch counting, linear measurement and cut-off, container filling, sheet counting, and machine cycling. Designed for automatic control of industrial processes, counter actuates equipment at any preset count from 2 to 100, at speeds faster than 1000 operations per minute. Standard Instrument Corp., 657 Broadway, New York 12, N. Y.

Circle 745 on Page 19

## Metal-Composite Laminate

for applications requiring  
periodic electrical contact

Metal-composite laminated plastics are available for applications requiring intermittent electrical contact. With the metal embedded in strong, durable insulation material, products supplement line of copper-clad laminates ordinarily used for etched printed circuits. They fill the need for metal-laminate combinations where more intricate, close-tolerance printed circuits are not required.



## Eastman 910 Adhesive solves another production bottleneck

The A. W. Haydon Company, Waterbury, Connecticut, makes a newly-designed timing device for automatic telephone switchboards.

The nylon timer gears and associated cams had to be molded separately due to their complex shape, then joined on an assembly-line.

Fast-setting, high-strength Eastman 910 Adhesive proved to be the economical, easy-to-use means of bonding these nylon parts.

In assembly, the gear and cam are held in a simple jig and a drop of adhesive is applied. The mating surfaces are brought together and held for a few moments. *Within 10 seconds a strong bond is formed, and the part is assembled into the timer.*

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problem can this unique adhesive solve for you?



For a trial quantity (1/3-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9108 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. M-8, Kingsport, Tenn. (Not for drug use) See Sweet's 1960 Prod. Des. File, 7/E

Circle 544 on Page 19



Theme Tower  
Symbol of  
the 1960  
Metal Show

## Learn a lot about design at the **NEW METAL SHOW!**

"ASM brings together in one place and at one time the year's most important developments in the technical and practical aspects of the metals industry. Never have I left a show without several ideas for applications of materials, equipment or processes in my engineering work. The 1960 Metal Show promises me more 'take home' than ever."



Raymond J. Hibbeln  
Dept. Chief, Product &  
Development Engineering  
**WESTERN ELECTRIC COMPANY**

Design engineering experts know the value of the 1960 Philadelphia Metal Show — how stimulating it will be — and that's why they plan to attend. They know that a new emphasis on the essential metals and materials, processes and techniques will make the 1960 Show more valuable than ever before . . . providing some 300 exhibits and 250 technical papers. Attendance will be a sound investment for you and your company!

**October 17-21**

**NATIONAL METAL  
CONGRESS and  
EXPOSITION**

**Philadelphia Trade & Convention Center**



Sponsored by the  
**AMERICAN SOCIETY FOR METALS**  
Metals Park • Novelly, Ohio

Circle 545 on Page 19

### NEW PARTS AND MATERIALS

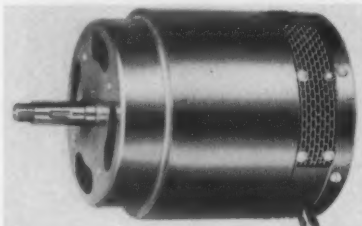
Metal-composite laminates are supplied in three versions: With metal inserted in windows which are cut in the top layers of the laminate; with metal pressed flush into the laminate; with a sandwich of metal foil between two layers of laminates which have been cut out at designated locations where electrical contact is desired. All composite laminates are custom-engineered to fit a specific application. Taylor Fibre Co., Norristown, Pa.

Circle 746 on Page 19

### Induction Motor

has high output for  
compact configuration

F-25-2 three-phase induction motor provides an exceptionally high output in an extremely compact configuration. Unit is intended for air-borne or ground-based axial-vane



blower applications. Measuring only 5 1/6 in. in diam by 9 3/16 in. long, motor weighs 17.72 lb and develops 12.4 hp. Kearfott Div., General Precision Inc., 1150 McBride Ave., Little Falls, N. J.

Circle 747 on Page 19

### Flow Regulator

for use in single-body  
or multivalve manifold

Precise flow regulation of fluids even under varying pressures is achieved with new cartridge flow regulator. Unit maintains constant flow to the system when the pump



**TUBING THAT KEEPS  
ITS TEMPER IN THE  
TOUGHEST SPOTS**



## PRECISION TUBING

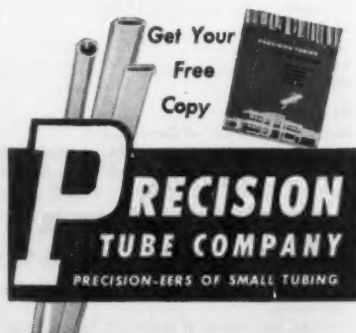
**Made To Your Product  
Requirements . . . Sold At  
Regular Prices**

The right temper in tubing can mean the difference in finished product quality. It should be varied to meet the job to be done.

Precision Tubing can be produced to meet your most exacting specifications from annealed to full hard. Continuous hydrogen atmosphere and combusted gas atmosphere bright annealing furnaces, scientifically controlled by advanced instrumentation assures the correct temper in every foot of tubing . . . locked in for the life of the tubing.

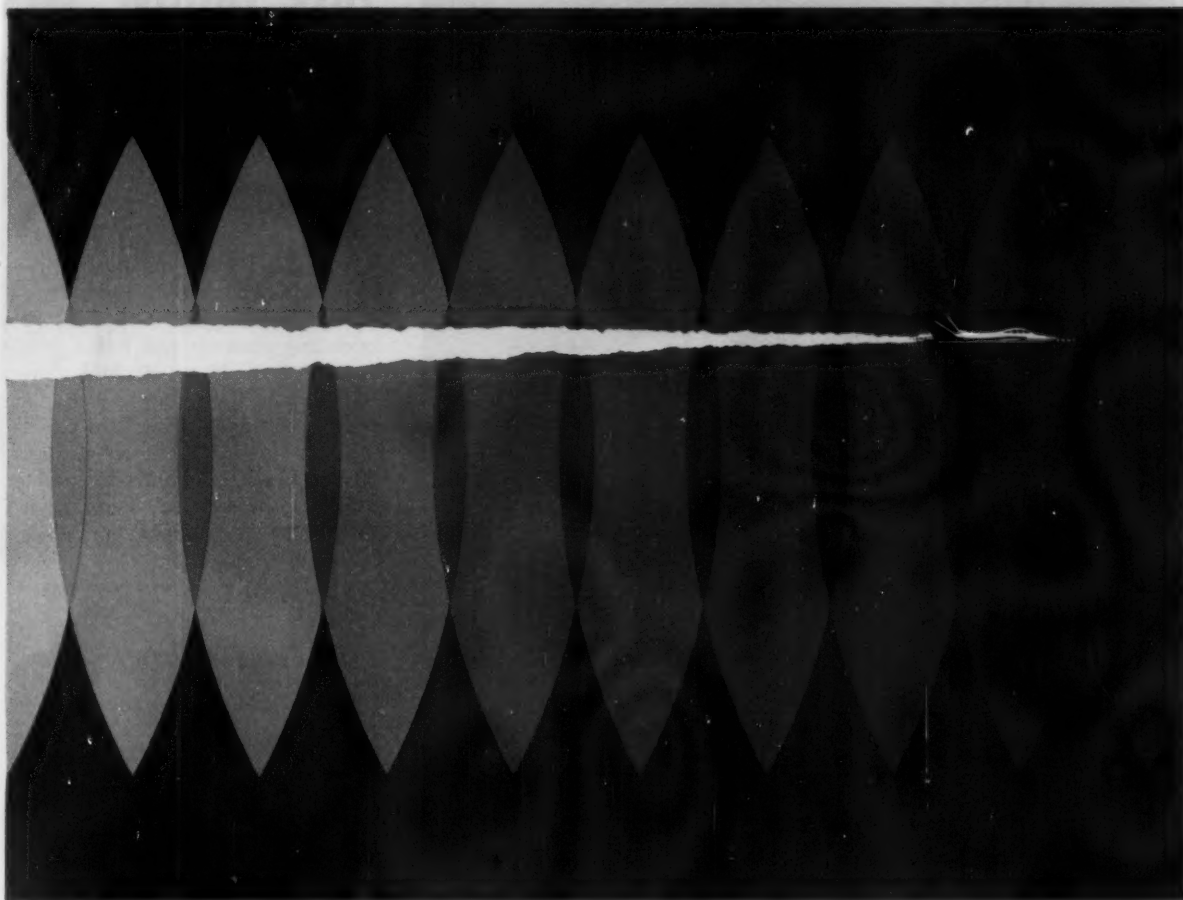
Precise temper is only one of the outstanding qualities of Precision Tubing. Accuracy, mirror-finishes, quick deliveries and regular mill prices are all offered in Precision Tubing . . . In copper, brass, bronze, nickel, nickel-alloy . . . sizes .010" to 1.125" O.D. in all shapes. Get the full details, write for catalog to

**PRECISION TUBE CO., INC.**  
North Wales, Pa.



Circle 546 on Page 19





## How a super alloy will hit Mach 3 from a vacuum start

Metallurgical Products Department reports on  
René 41\*—and on how its unique properties make it ideal  
for use in everything from jets to machine components

When machine-component specifications call for the "impossible"—top strength combined with high temperature resistance and minimum weight—a vacuum-induction-melted alloy may be the answer.

René 41—General Electric's super alloy—finds wide application in machine design as well as in jet engine components. Virtually free from impurities, René 41 can be successfully forged, welded, or formed; offers top tensile and stress rupture strengths, increased

ductility. All this with minimum weight—a combination found in no other alloy!

Got a design problem? Choose from General Electric's variety of high-purity, vacuum-induction-melted alloys in sheets, bars, billets, wire, or castings. For detailed information—or the assistance of one of our engineers—write today to: *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile Street, Detroit 32, Michigan.*

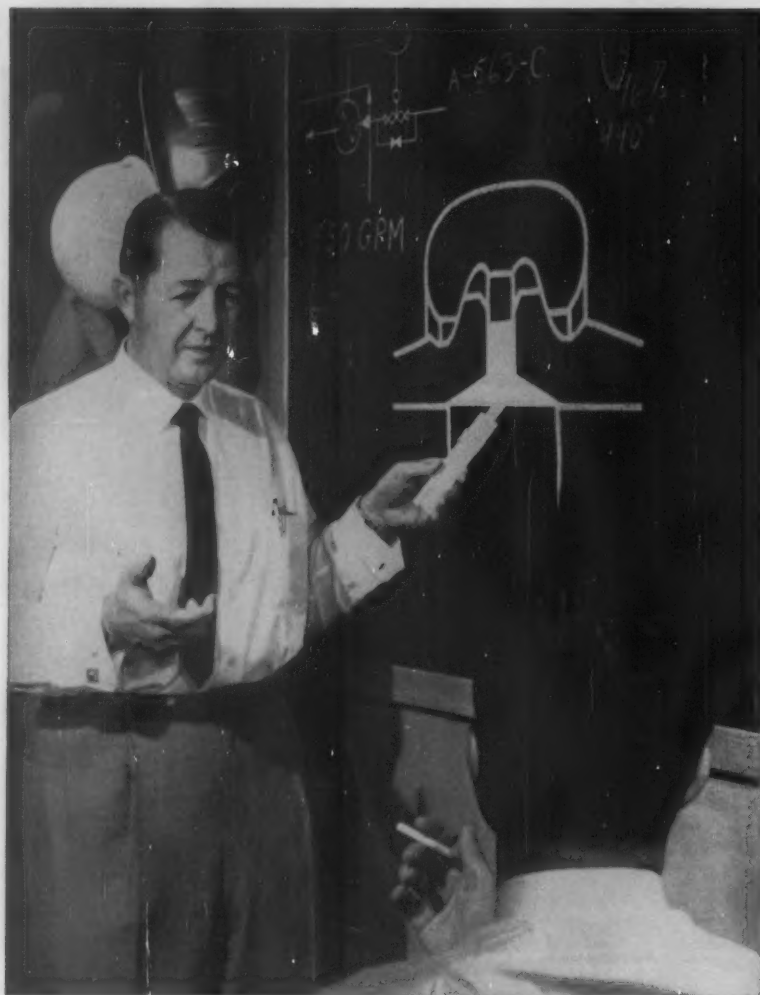
\*René 41 is a trademark of the General Electric Company

METALLURGICAL PRODUCTS DEPARTMENT

**GENERAL  ELECTRIC**

CARBOLOY® CEMENTED CARBIDES • MAN-MADE DIAMONDS • MAGNETIC MATERIALS • THERMISTORS • THYRITE® • VACUUM-MELTED ALLOYS





## New GRAYLOC® Seal Eliminates Leaks

GRAYLOC is practical where leakage is a problem, regardless of high or low pressure, where savings in money, space, weight or time are desirable.

The GRAYLOC seal design, a new principle in pipe connection, is simple: tapered lips on either side of a rigid rib. The seal lip tapers slightly less than the mating hub, forming a line seal as the components touch. As the connection bolts are tightened, the lips deflect to form a positive, leak-proof surface seal. GRAYLOC Connections can be made and released repeatedly and still operate to pressure without seal ring replacement.

GRAYLOC works in most flange applications. If you are interested in more information about how GRAYLOC can solve your leakage problems and save you money, write for the new GRAYLOC CATALOG on your company letterhead. No charge, no obligation.



GRAYLOC SALES DIVISION

*Tool Company*

P.O. BOX 2291

HOUSTON 1, TEXAS

REpublic 4-1641

## NEW PARTS AND MATERIALS

output or the upstream or downstream pressures vary. Used in a single body or a multivalve manifold, valve is available in a wide range of flows from 0.1 to 6.5 gpm. While the regulated flow is factory-set, regulator features an external adjusting screw that permits field adjustments of  $\pm 10$  per cent for flows 0.1 to 1.5 gpm and  $\pm 5$  per cent for flows 1.5 to 6.5 gpm. Regulator accommodates 0 to 2000 psi operating pressure and has a pressure drop of 25 psi at high flows and 50 psi at low flows. Weighing only 4 oz, regulator is hard-coated aluminum and passivated stainless steel. It handles all fluids compatible with these materials. **Fluid Regulators Corp.**, 313 Gillette St., Painesville, Ohio.

Circle 748 on Page 19

## Epoxy Casting System

for high-temperature use

Meta-Cast 405AP is a general-purpose, 100-per cent solids, filled epoxy-resin casting system which can be used over a wide temperature range. It contains no solvents, reactive diluents, or other degrading adulterants. Excellent adhesion and chemical resistance, and very good mechanical strength, coupled with excellent machinability, make the compound suitable for most casting, potting, and encapsulating operations. **Metachem Resins Corp.**, 530 Wellington Ave., Cranston, R. I.

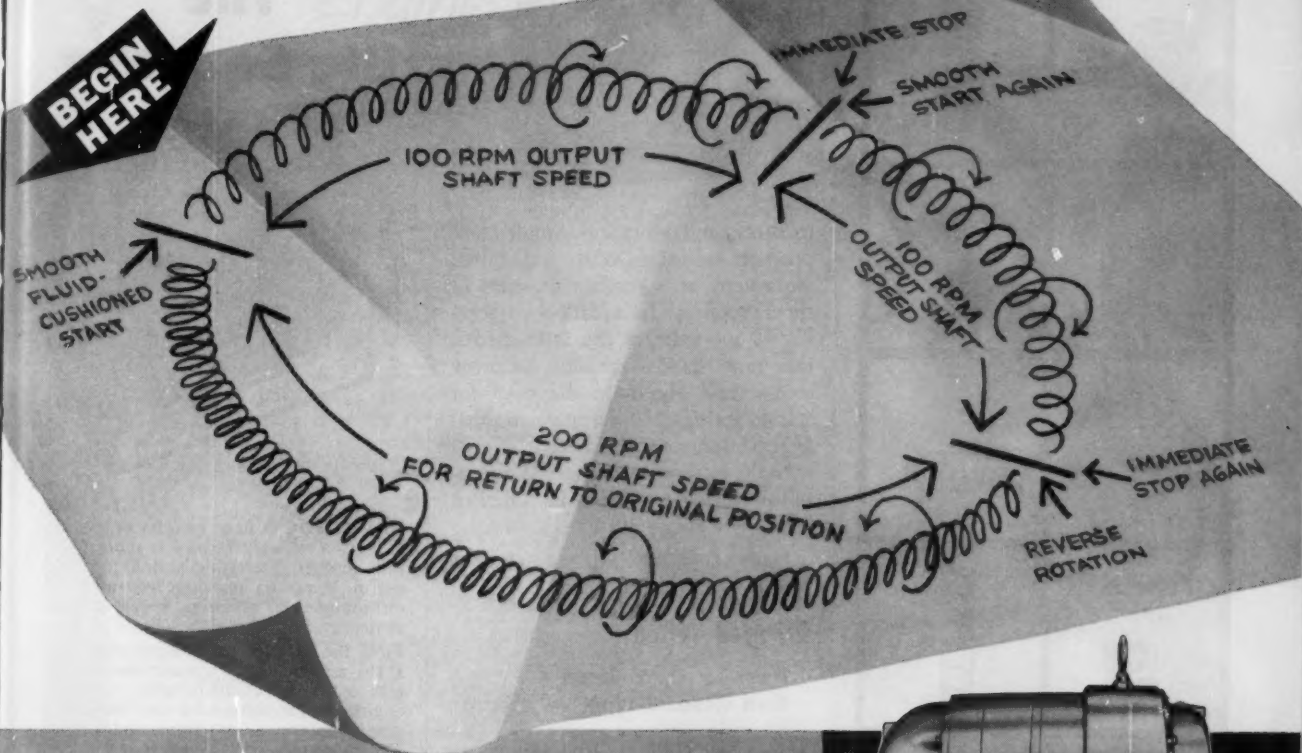
Circle 749 on Page 19

## Ammeters, Voltmeters

have taut-band suspension system

Type KA-241 circular-scale, 250-deg switchboard ac ammeters and voltmeters employ the taut-band suspension system which uses no pivots or bearings and is completely free from rolling and sliding friction. Instruments withstand severe vibration and shock without any effect on their accuracy. Moving element is supported at each end by high-tensile metal bands. Bands are permanently anchored to the moving element and to U-shaped springs that maintain proper band tension and contribute to immunity

# How would you solve this 5-stage drive cycle?



## This one modern Reuland power package does all five!

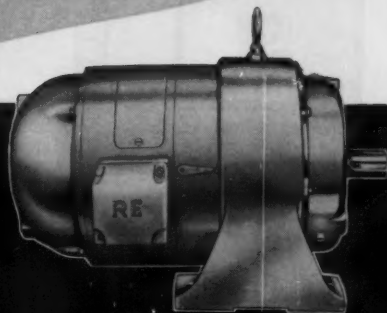
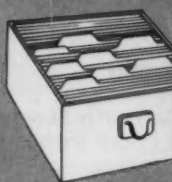
Today's ingenious, automatic machines have demanded a whole new concept in electric motors. No longer will "just any motor do" because the motor now becomes merely an integral part of the modern drive package.

Reuland's "Xpandable Design" idea originated this modern new approach several years ago. With this unique system, drives incorporating many

varied factors are supplied as a single unit . . . tailored to the needs of each individual customer.

Modern Reuland Power demonstrates every day that there is something new in electric motors. Whether your own drive needs are more complicated, or less, than the above sketch . . . it will pay you to take stock and compare with what Reuland can offer.

Our New General Catalog Will Come In Handy — Sent FREE On Request Gives details on Reuland's "Xpandable Design" . . . also shows how O.E.M.'s save money by using Reuland's free "Special Motor Library." Get a copy for your files now, for sure.



### MODERN REULAND POWER

This unit contains an internal fluid coupling . . . a two-speed reversing duty motor . . . gear reducer . . . and magnetic brake mounted between the reducer and the fluid coupling. It is typical of the literally hundreds and hundreds of tailored adaptations available as a result of Reuland's modern "Xpandable Design" idea.

It is easy to see how this one, compact drive package saves costs and space and weight in comparison to installing separate drive units.



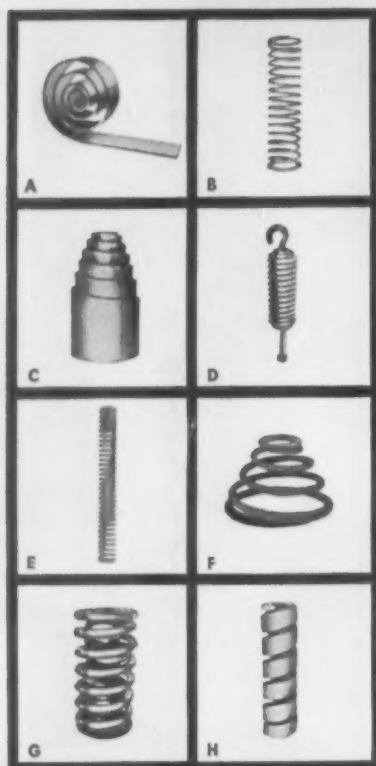
MODERN POWER FOR MODERN-DAY PRODUCTS

# REULAND MOTORS

REULAND ELECTRIC COMPANY  
WESTERN DIVISION: Alhambra, California  
EASTERN DIVISION: Howell, Michigan  
DISTRIBUTORS IN ALL PRINCIPAL CITIES  
Refer To Sweet's Product Design File, Section 5a

★ REGISTERED TRADEMARK

Can you identify  
these springs?



A. flat B. helical C. volute D. extension  
E. helical F. cone G. helical, triple-coil  
H. rectangular section

## Over One Million ALCO SPRING DESIGNS

ALCO's complete line of "performance-rated" springs ranges from small springs for light work to heavy-duty triple-coil springs for heavy, sustained work.

In over 80 years, ALCO engineers have produced more than one million spring designs to serve almost every conceivable application.

For your next spring job, contact your nearest ALCO sales office. To obtain brochure, *ALCO Springs for Industry*, write to ALCO Products, Inc., Dept. 160, Schenectady, N. Y.



**ALCO PRODUCTS, INC.**  
NEW YORK  
SALES OFFICES IN PRINCIPAL CITIES

Circle 550 on Page 19

### NEW PARTS AND MATERIALS



to shock and vibration. Small stops prevent excessive axial and radial movement as a further measure of shockproofing. In addition to serving as the axle for the instruments, the taut bands provide restoring torque and eliminate the need for spiral springs. Voltampere burden of the instruments is lower than that with pivot-jewel design. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

Circle 750 on Page 19

### Oriented Teflon

keeps its shape better  
than standard types

Teflon sheet has undergone an orienting process which substantially reduces both initial deformation and long time creep. Smoother surface produced by the orienting process also permits gaskets to achieve better seals at lower bolting loads. Oriented material minimizes the need to retighten flange bolts and fasteners. Loadings on oriented Teflon gaskets can be increased by as much as 25 per cent without increasing the percentage of deformation. Oriented Teflon is available in thicknesses from 1/32 to 2 in. and in sizes to 48 x 48 in. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich.

Circle 751 on Page 19

### Elapsed-Time Indicator

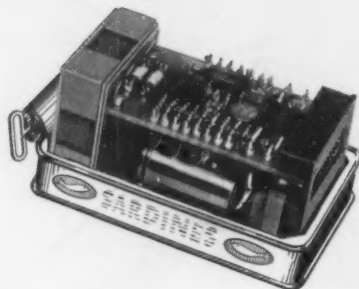
is a subminiature,  
expendable unit

Improved subminiature Chronistor elapsed-time unit indicates the elapsed operating time of any electrically operated equipment. Device operates on the electroplating principle in that the current flowing through the cell plates copper off



### SPECTROL PRECISION MECHANISMS

## The Big Squeeze Job



**SPECTROL'S** new PRECISION MECHANISM—a velocity servo—is more than just another interesting shrink job. It's useful. It can go anywhere you need an ultra-miniature, precision speed control device.

First, the package. It measures only 1½ x 1½ x 3 inches. In a space that would give a sardine claustrophobia, Spectrol engineers squeezed a solid-state amplifier, a servo-motor, a gear train, and a very special, condensed (½-inch long) potentiometer and switch.

The pot has four electrically isolated wipers, all riding 90° apart on the same coil. The switch, in the same pot housing, has four wipers riding on an alternately conducting and non-conducting surface.

**THE FUNCTION:** The servo accepts dc signals varying between ±10 v from a computer to drive the pot in such a manner that speed is directly proportional to the dc signals.

**THE APPLICATIONS:** Here's an example: tied to an airborne computer, the Spectrol servo will drive a scope in the cockpit of one of the nation's hottest aircraft. The object: to give the pilot a visual, three-dimensional analog of his position. Actually, the servo will drive anything—resolvers, synchros, tachs, other pots and switches. It's a complete, ready-to-go package you can put into your system as is.

This is another example of how Spectrol PRECISION MECHANISMS free the systems engineer from building functional sub-assemblies using components such as gear drives, clutches, precision potentiometers and servomotors. If you need modules combining any of these components in a single specification—Spectrol can help.

For more details, call your Spectrol engineering sales representative, or address Dept. 63.



**ELECTRONICS CORPORATION**  
1704 SOUTH DEL MAR AVE. • SAN GABRIEL, CALIF.

Wescon Booth 1004

Circle 551 on Page 19

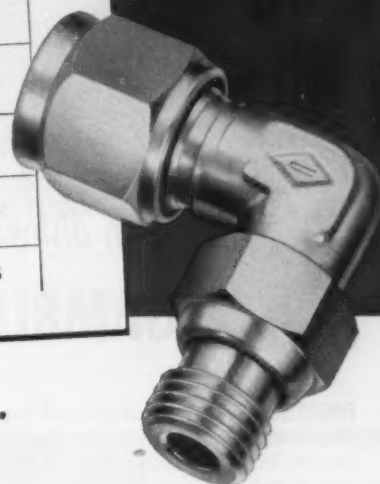




# IMPERIAL *Engineering and Data File*

## DURA-TITE TABLE OF COMPARISON

Features	TYPE OF PORT SEAL		
	Pipe Thread	"O" Ring	Dura-Tite
Permits angular positioning of fitting with no possibility of leaking	no	yes	yes
Suitable for use with all hydraulic fluids without changing components	yes	no	yes
Safety from seepage up to 20,000 psi	no	no	yes
Can be reconnected repeatedly without changing sealing element	no	no	yes
Withstands high pressures to temperatures of 300° F	no	no	yes
Simple to install — no loose parts	yes	no	yes
Usable with SAE standard straight thread boss	no	yes	yes
Unlimited shelf life	yes	no	yes
No deterioration of sealing element due to aging	yes	no	yes
No possibility of damaging sealing element in assembly	yes	no	yes



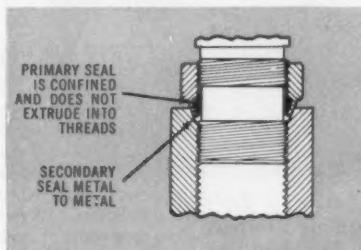
**HOLDS PRESSURES TO 20,000 PSI...**

## NEW DURA-TITE IS INDUSTRY'S MOST FOOLPROOF PORT SEAL FOR TUBE FITTINGS!

From Imperial research comes a new, more effective and far more simplified port sealing method for tube fittings. As you can see on the chart pictured above, Dura-Tite does everything an "O" ring fitting will do—and much more—without requiring any special skill or care.

Even at pressures up to 20,000 psi, Dura-Tite provides a positively seeproof seal, and the fitting can be positioned in any direction without impairing tightness. And, because Dura-Tite's polyamide split ring seal is confined, it cannot distort or extrude into threads. The joint can be opened and remade at least 25 times without seepage.

Note how Dura-Tite creates a double seal with a single, simple operation. The fitting comes complete, with no additional parts to



be added in the field. It uses any standard SAE straight-thread port. No special machining is required.

The special polyamide sealing medium contained in Dura-Tite will outperform any "O" ring compound. It has no hydraulic fluid limitations, being highly resistant to most chemicals. Solves temperature problems, too. Tests have shown that the Dura-Tite seal will withstand high pres-

ures at temperatures up to 300° F. There is no need for periodic replacement because of deterioration on the job.

Dura-Tite port seals can be obtained in both Imperial Hi-Seal flareless and 37° flared tube fittings in steel and stainless steel. And, Dura-Tite costs no more than "O" ring seals but makes important savings in installation.

### IT'S IN THE BOOK

Dura-Tite port seals are covered in Imperial's new Hi-Seal catalog No. 3108 and in Bulletin EPR-2. Send for copies today.



**THE IMPERIAL BRASS MANUFACTURING CO.**  
Dept. MD-80, 6300 West Howard Street  
Chicago 48, Illinois





*from dishwasher tops...to barge skegs...*

## **GAMBLE solves problems with WOOD!**

**PROBLEM:** Wood cutting-board tops of automatic dishwashers were splintering—and even distorting the machines themselves—from tangential swelling and shrinking of the tops.

**SOLUTION:** Gamble wood engineers developed a strip-constructed board, with edge grain exposed, which is now in volume use.

**PROBLEM:** The solid wood skegs (outer keel) of assault barges were cracking and splitting on beach landings.

**SOLUTION:** The *first* laminated skag was researched and developed—then built in quantity—by Gamble Brothers.

Design problems like these are “all in a day’s work” to the wood engineers at Gamble Brothers—a unique organization designing and building a wider variety of wood products than any other

U. S. woodworking company. Today they’re working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

### **FREE booklet illustrates GAMBLE services**

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4619 Allmond Ave., Louisville, Ky.



*If the problem involves wood, Gamble can help!*

# **GAMBLE BROTHERS, INC.**

4619 Allmond Avenue, Louisville, Kentucky



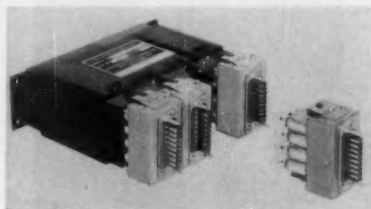
the anode and onto the cathode. Scale calibrated in hours alongside the anode gives a direct, easy reading of how long current has been applied. Current required is approximately 1 ma (depending on full scale hours) at any voltage greater than 6 v dc. Unit fits into any ordinary 3AG cartridge fuse clip and requires no major modification of equipment into which it is installed. Full-scale hours from 100 to 10,000 are available from stock, and units are hermetically sealed. Operating temperature is from 0 to 55 C, with wider-temperature-range units available on special order. Simple half-wave rectifier in series easily converts the unit to ac operation. **Bergen Laboratories**, 247 Crooks Ave., Clifton, N. J.

Circle 752 on Page 19

### Digital Display

with wiring potted to customer specifications

Plug-In digital display, Series 10000P, is now available with a quick-disconnect feature for in-the-field lamp servicing without disturbing internal wiring of the equipment in which it is being used. Lamps or the entire display unit can be changed rapidly on the spot. Wiring can be potted to customer specifications and is completely covered, whether potted or unpotted. Display operates on a rear-projection principle. When one of the twelve lamps at the rear of the unit is lighted, it projects a corresponding digit or character onto the front viewing screen. Size of the digit or

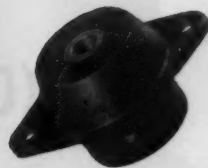


NEEDED:  
ISOLATION FROM  
HIGH ENGINE TORQUE  
AND SHOCK



...to isolate frame and operator from the high engine torque, shock and violent bursts of intermittent power delivered by the engine on a 6-ton crawler-tractor; also to protect engine from shock of heavy pounding.

ANSWER:  
STANDARD  
MB ISOMODE<sup>TM</sup>  
TYPE 5 MOUNTS



The Isomode Type 5 Mount isolates equally the six possible modes of vibratory motion. With core in balanced compression and shear, it offers high load capacity and endurance in compact size. It is safely self-snubbing to control damaging overloads. And it can take an extraordinary amount of punishment.

WHAT'S YOUR  
MOUNT PROBLEM?



MB has specialized in vibration isolation for over 20 years. It may very well be that an existing standard MB mount or modification thereof is the answer to your vibration control problem. If not, MB has the experience and personnel to find the right answer for you. Write us for complete information—ask for Bulletin 418-1.

**MB ELECTRONICS**

A DIVISION OF TEXTRON ELECTRONICS, INC.  
1056 State Street, New Haven 11, Conn.

## Stainless Steels

Monel

K-Monel

A-Nickel

Duranickel

Inconel

Inconel-X

Excelsior-  
(Copper Nickel)

D-Nickel

Incoloy

Permanickel

Phosphor Bronze

Nickel Silver

Cupro Nickel

Carbon Steel

### For FINE WIRE, ORDER RIVERSIDE-ALLOY

Contact Riverside-Alloy for the exact alloy you need in diameters as fine as .0025". Your order will be put-up on the spool, coil or Pay-Off-Pak best suited to your production facilities.

Phone, wire or write: *Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N. J.*

RIVERSIDE-ALLOY



METAL DIVISION

**H.K. PORTER COMPANY, INC.**

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

#### NEW PARTS AND MATERIALS

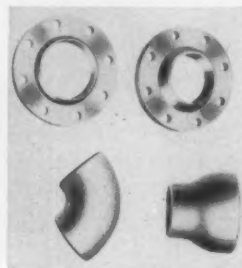
character displayed is 1 in. high. Dimensions of the individual plug-in unit are 1 9/16 in. wide, 2 5/8 in. high, and 6 9/32 in. long. **Industrial Electronic Engineers Inc.**, 5528 Vineland Ave., North Hollywood, Calif.

Circle 753 on Page 19

#### Welding Fittings

are aluminum in  
2 to 8-in. sizes

Cast-pipe aluminum fittings are cast in aluminum 356-T6. They in-



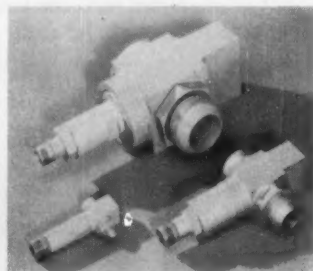
clude four types of welding reducers: Welding elbow, welding neck flange, slip-on welding flange, and blind flange. All fittings are available from stock in six sizes from 2 to 8 in. **Wheaton Brass Works**, Springfield Rd., Union, N. J.

Circle 754 on Page 19

#### Explosive Valves

with reusable bodies  
and replacement kits

Normally closed Con-O-Cap explosive valves are dead-tight, shut-off units for long or short-time storage of gases or liquids to 5000 psi. They operate in 0.002 second by firing a small, completely contained explosive squib. Dual primers provide a reliability factor of 99 + per cent at -65 to +160 F temperature range. Available replacement kits have only two parts, cap and trigger, which quickly replace the fired parts





**Miniature Soldiers.** Army ants carry out intricate maneuvers of wheeling, flanking, and envelopment with faultless precision. Their columns are led by "majors", preceded by "scouts". Raids are conducted by "skirmishers". Between campaigns, they form "bivouacs". Army ants are nature's tiny troopers.



**Miniature Ball Resolver,** approximately  $3\frac{3}{8}$ " x  $2\frac{1}{2}$ " O.D. continuously calculates position of aircraft and missiles traveling at supersonic speeds. MPB bearings at critical points keep torque low, and help make possible an accuracy of 0.33 of 1%. This is another man-made miracle in miniaturization.



**Man with Miracle.** This is Dick Anderson, one of MPB's Sales Engineers, whose cooperation with customers includes expert aid in the application of miniature and instrument bearings. MPB's technical staff, most experienced in its field, can assist you with your own miracles in miniaturization.

## Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS



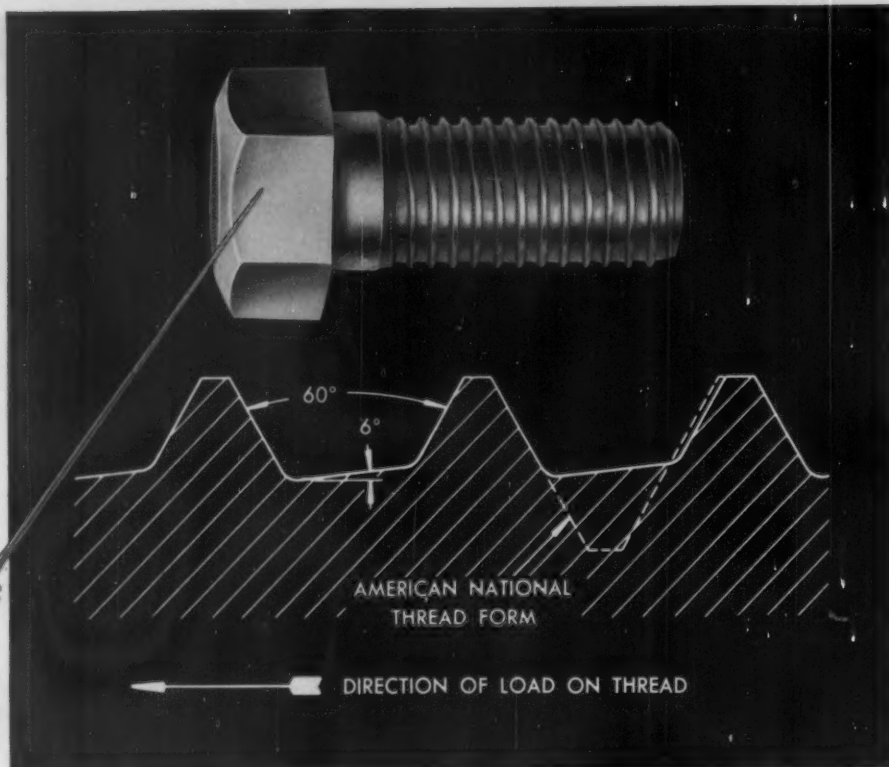
IN BALL RESOLVER SHOWN ABOVE

Every day man's advances, both on this planet and beyond, are opening new and challenging areas of application for miniature components and mechanisms. And at each step forward, MPB is ready to help with research, engineering and manufacturing facilities unsurpassed in the miniature bearing industry. MPB makes more than 500 types and sizes of bearings ranging from  $\frac{3}{8}$ " O.D. down, meeting requirements of the most exacting nature. Specials developed on request. For a confab on design problems or our latest catalog write **Miniature Precision Bearings, Inc.**, 108 Precision Park, Keene, N. H.

**MPB** Helps you perform  
miracles in miniaturization



NAT'S  
quick facts  
about  
Fasteners...



## Can **any** fastener actually **become tighter** in service?

WELL, HARDLY. NOT JUST *ANY* FASTENER...

But self-locking, extra-strength LOK-THRED® bolts, studs and screws *do*, and even after long service you can expect their breakaway removal torque to average about 70% higher than at installation.

Here's the reason. Just take a look at the LOK-THRED profile. Notice the extra-wide root? And its converging angle? It's held, strictly by design, to exactly 6 degrees.

Now, see what happens, as you drive any LOK-THRED fastener. It re-forms the metal of the receiving thread, squeezing out every void, and forming an intimate metal-to-metal contact. And each of the angled roots becomes a 6-degree tapered wedge, with the loading constantly pulling against it to make its anchorage even firmer.

That's why LOK-THRED fasteners actually *do* become tighter in service. They're self-sealing, too... fluids can't leak past them. And yet they're fully reusable... require no selective fits... can be used with ordinary tools.

Take our word for it, there are plenty of reasons\* why LOK-THRED is superior for many kinds of fastening... and we'll be glad to help you develop any applications to your own products.

\*They're all given in National's LOK-THRED booklet, with plenty of supporting data. Write for your copy.



The National Screw & Mfg. Company • Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California

in the reusable body, permitting re-use of valves. The 13 standard valve models accommodate every standard AN tube size from  $\frac{1}{8}$  through 2 in. OD and are made of aluminum or stainless steel. Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.

Circle 755 on Page 19

### Inertial Dampers

can be coupled to servo motor in seconds

No. 1D-15-100 size 15 inertial damper can be coupled to the mating servo motor in a matter of seconds. Motor mounting register fits into the rear of the damper, and pinion drives the damper element. Output shaft and mounting register of the damper are identical to those



of the motor. Thus the damper can be used without mechanical changes in an existing gear train to raise the loop performance above that possible with a simple motor. Dampers are also available for size 11 and size 18. These units work equally well with 60 or 400-cps servo motors. All are made to precision tolerances and function over a wide operating and environmental range. Component Div., Industrial Control Co. Inc., Central Avenue at Pinelawn, Farmingdale, N. Y.

Circle 756 on Page 19

### Insulating Material

is useful to 2200 F

Tipersul fibrous potassium titanate is a crystalline fiber material for high-temperature applications, such as thermal, acoustical, and electrical insulation, as well as for filtration applications. Another use for the material is in ablative insulation which absorbs heat and limits heat penetration, protecting space hardware from high temperatures for

**TOKHEIM** QUALITY BUILDS PERFORMANCE  
IN ... AND MAINTENANCE OUT ...

IN NEW

"MIRACLE METER"

WITH

**RULON**® CUP PACKING ...  
AND 9 OTHER RULON PARTS

TOKHEIM CORP. of Fort Wayne, Ind., leading manufacturer of gasoline pumps, needed a tough material for the cup packing of their new meter's plunger-assembly. Only Dixon's Rulon (reinforced Teflon) had the right combination of chemical and physical characteristics to withstand attack from all types of gasoline additives, and also stand up under the mechanical stress and wear of millions of plunger cycles. As a result of Rulon's performance, it is used in 9 other places as shaft seals, thrust washers and sleeve bearings:

- **RULON resists deformation** — hugs cylinder walls, prevents leakage, maintains meter accuracy.
- **RULON reduces drag** — low coefficient of friction insures smooth operation—even in non-lubricating media (gasoline).

cient of friction insures smooth operation—even in non-lubricating media (gasoline).

- **RULON wears longer** — tougher than Teflon, Rulon cuts costly maintenance ... requires no lubrication.

- **RULON is completely inert** — doesn't change properties or swell in presence of liquids.

Look at your designs with RULON in mind. If it's a bushing, bearing, cam, wear strip, or insulator, chances are the combination of the correct RULON formulation plus DIXON's manufacturing capabilities can produce the exact component you need. \*One of Dixon's many modifications of DuPont TFE Teflon.

For engineering data sheet 129-8, write ...

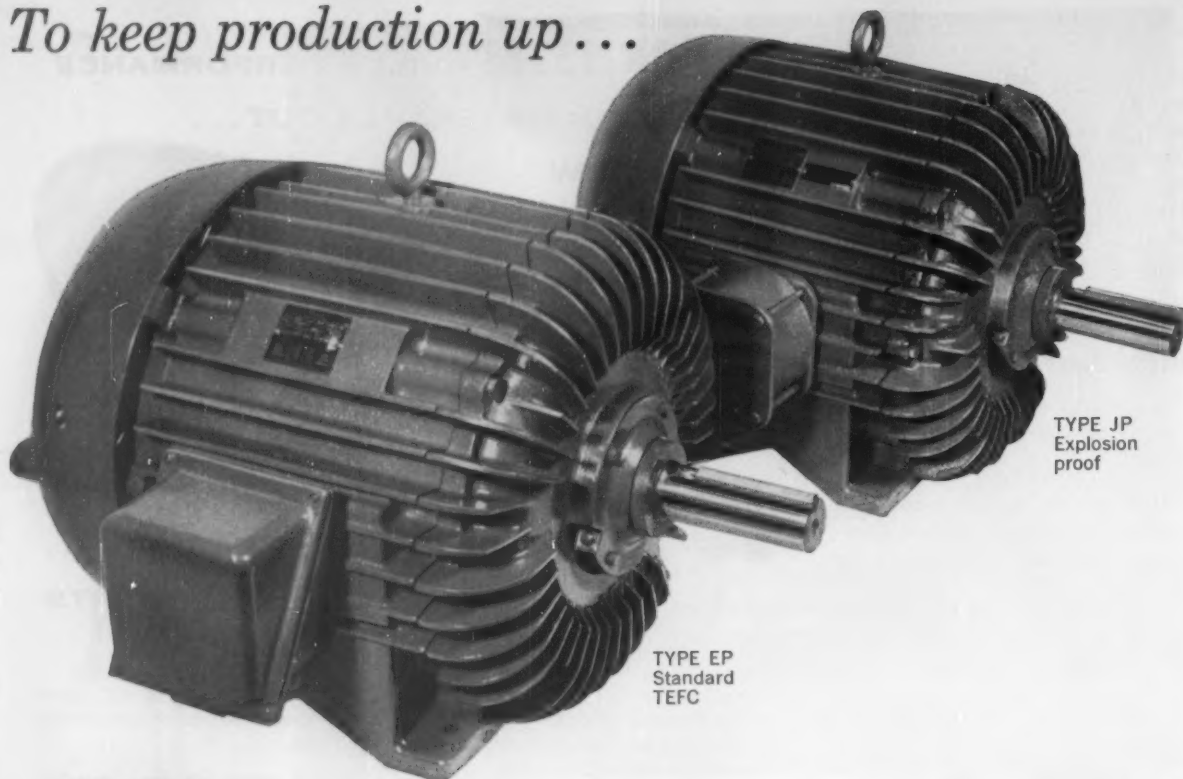
**Dixon**

**DIXON CORPORATION**  
Bristol, Rhode Island

Check these  
outstanding  
properties of  
**RULON**

- Resistance to wear: 500 times Teflon
- Low coefficient of friction: 0.10-0.24
- Wide temperature range: -300° to +500°F
- Excellent electrical properties: Resistivity  $10^{15}$ , dielectric constant 2.6, dissipation factor .002
- Chemically inert — Zero water absorption — Weather resistant
- Low coefficient of expansion:  $3.3 \times 10^{-5}$  ( $\frac{1}{2}$  that of Teflon)
- Low deformation under load:  $\frac{1}{2}$  that of Teflon

*To keep production up...*



## PICK FROM THIS PROTECTED PAIR...

Here's a power-packed pair of Wagner® totally-enclosed fan-cooled motors —Type EP, standard, protected against damage from dust, abrasive, fumes, steel chips or filings; and Type JP, explosion-proof, for safe use in specified hazardous locations.

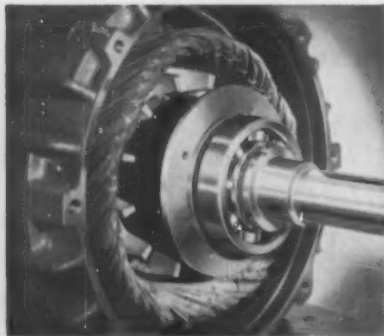
They'll keep your production rates up, delivering full rated horsepower under the toughest conditions . . . staying on the job with dependable, continuous service that means peak output. They're the perfect pick, for individual machines or for automated lines.

In the design illustrated, these motors are built in ratings through 100 hp in NEMA frame sizes 182-445U. Let your Wagner Sales Engineer show you how this protected pair (or larger Wagner enclosed motors through 500 hp) gets the job done. Call him, or write us for Bulletin MU-224.

### Wagner Electric Corporation

6404 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

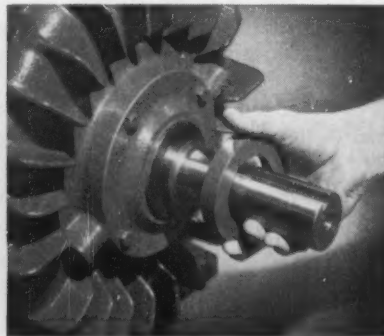
WM60-19



**HEAVY-DUTY BALL BEARINGS...** The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long, troublefree service under heavy loads.



**BEARINGS CAN BE RELUBRICATED...** Factory lubrication will last for many years under normal service, but openings are provided to permit relubrication that adds years to motor life under severe conditions.



**SECURELY SEALED FOR LOW MAINTENANCE...** Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

**VISIT WAGNER BOOTH 260 AT THE PRODUCTION ENGINEERING SHOW**



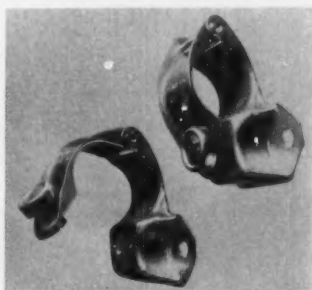
brief periods. Material, useful to 2200 F, offers low heat conductivity, ability to scatter infrared radiation, and low density. The small, white crystalline fibers are available in lumps and loose fibers, as well as blocks, sheets, and paper forms made by standard felting techniques. Curved or odd shapes are also available. E. I. du Pont de Nemours & Co., Wilmington, Del.

Circle 757 on Page 19

### Quick-Operating Clamps

for wire bundles, hose, cable, and conduit

No. 7C1 quick-operating clamps are available to speed up installation and maintenance of wire bundles, hose, cable, and conduit. Clamps permanently mount to structure with one rivet or bolt. Material held



is easily installed or removed after clamps are mounted. Vibration-proof, quarter-turn fasteners are used in the clamps. Wide clamping area and rounded edges prevent scarring or cutting. Sizes range from 1/4 to 1 1/2-in. diameters. Camloc Fastener Corp., 22 Spring Valley Rd., Paramus, N. J.

Circle 758 on Page 19

### Steel-Armored Hose

resists fire, heat, mechanical damage

Synflex Hi-Temp with outstanding resistance to fire, heat, and mechanical damage is available for paint-carrying lines, chemical lines, and for the handling of flammable fluids. Outer protective covering is 0.012-in. galvanized steel armor. Central core is a specially formulated seamless-nylon tube, covered with black vinyl, wrapped with Mylar-backed asbestos tape. Hose is

## FROM FIXED DRIVE TO ADJUSTABLE CENTERLESS FEED



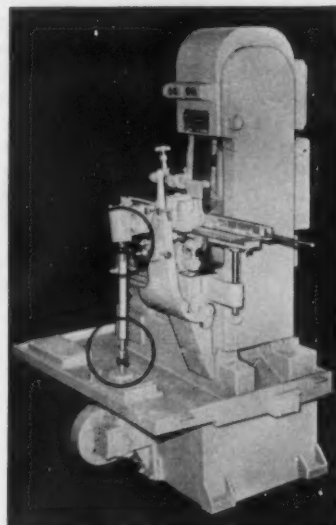
## APEX UNIVERSAL JOINTS

The rate of feed on Production Machine Company's finishing and polishing machines is readily adjusted by tilting the centerless feed housing. Two Apex universal joints—one connected to a fixed motor shaft, a second connected to the adjustable feed unit—provide quiet, efficient operation at any adjustment angle.

And because finishing and polishing metal, fibre, plastic, rubber and wood create an abrasive atmosphere of tiny particles, these are Apex covered universal joints . . . all abrasive particles are sealed OUT, clean, sustained lubrication is sealed IN.

Apex covered universal joints operate in fluids, gases, corrosive or abrasive atmospheres, and in extremes of temperatures. Apex universal joints, covered or uncovered, 1/4" to 4" diameter stock sizes, full range of hub types.

PHOTO COURTESY PRODUCTION MACHINE COMPANY



or write, on your company letterhead please, for Catalog 28 and Data Sheet. For special applications, send sketch or print for prompt recommendations and quotation.

THE  
**APEX**  
MACHINE & TOOL CO.  
1042 South Patterson Blvd.  
DAYTON 2, OHIO



Phantom view of Apex universal joint with lubricant-retaining cover, an exclusive Apex development. Apex covered joints operate efficiently in wet, dry, corrosive or abrasive atmospheres and in extremes of temperatures.



## AROUND THE CLOCK PERFORMANCE

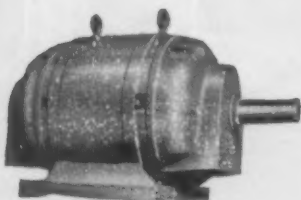


*that's what you  
get when you  
Specify ...*

## VALLEY BALL BEARING MOTORS

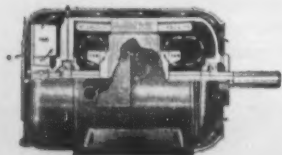
### HERE'S WHY...

First of all they are specifically engineered to meet the exacting requirements of most power needs—regardless of type or location. Then too, they insure constant, uninterrupted service in high temperatures because they are always cool running. Having enclosed ball bearings you are assured of complete protection against harmful dust and grit. Furthermore, they can handle most power load emergencies without damage to its operating parts.



### FAN COOLED

Totally enclosed VALLEY Motor Polyphase, 50 to 60 cycles, constant speed, continuous duty, squirrel cage induction, high torque, low starting current and fully ball bearing, 2 to 60 h.p.



## VALLEY

ELECTRIC CORPORATION  
4221 FOREST PARK BLVD. • ST. LOUIS 8, MO.

Circle 562 on Page 19

## NEW PARTS AND MATERIALS



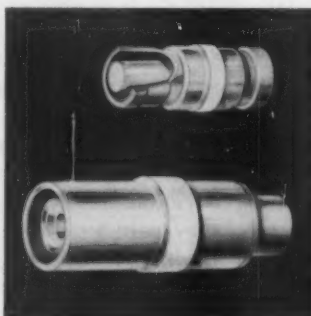
flexible and contours readily to existing equipment. It is available with ID of  $\frac{3}{8}$  in. and OD of 0.718 in. Synflex Products Div., Samuel Moore & Co., Mantua, Ohio.

Circle 759 on Page 19

### Ceramic-Metal Seal

for insertion into  
envelope structures

Ceramic-metal seal composite is suitable for insertion into envelope structures by use of high-temperature braze material. Primary ceramic-metal seal, with Stress-Float construction, is relatively isolated from terminal and envelope stresses.



This permits the use of large-diameter copper leadthroughs and high-temperature seal-in procedures. Typical seals have copper studs of  $\frac{1}{8}$  and  $\frac{1}{4}$ -in. diam. CFI Corp., Cottage Place, Mineola, N. Y.

Circle 760 on Page 19

### Mounting System

for airborne equipment  
uses structural damping

Model 2678-1 mount utilizes structural damping in conjunction with all-metal resilient elements. Met-L-Damp employs a dynamic interaction between viscoelastic layers situated between metal structural members and stainless-steel wire cushioning elements. Center-of-gravity mounting system is designed

# TIPS AND TECHNIQUES

## VOLUME II ENGINEERING AIDS

- Simplifying Constructions
- Utilizing the Slide Rule
- Construction Aids
- Shortcuts for the Engineer

Helpful Tips and Techniques that apply to engineering methods, are now available in this one-volume reference. This manual contains 32 pages of illustrated time-and-money saving procedures that every engineer can use.

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### MACHINE DESIGN

Reader Service

Penton Building

Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order)

**MODERN EQUIPMENT PRODUCES**

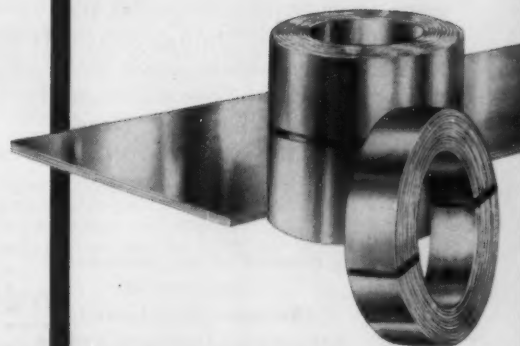
# *Quality Aluminum*



**E**XACT quality control on every order of aluminum sheet and coil is assured by modern laboratory equipment manned by Quaker State's experienced technicians. Modern "miracle" machines such as the quantum-meter illustrated above which measures the alloy content to within 1/1000 of 1% . . . and the porosity detector which indicates the slightest amount of gas in the melt . . . are just two of many testing machines used in controlling our quality.

Every order of aluminum shipped by QSM has been tested for hardness, tensile strength and elongation. If desired, QSM will provide certified laboratory reports of the physical properties and chemical analysis on every order.

If quality is important to you, and we know it is, call Quaker State for your next order of aluminum sheet or coil.



**QUAKER STATE METALS CO. • LANCASTER, PA.**

*Division of HOWE SOUND COMPANY*

*Mill Producers of Aluminum Sheet and Coil*

Circle 563 on Page 19

# Reliance Super 'T' V\*S Drives

## Automatic process control from standard off-the-shelf components



Installing Reliance Sealpak Unit on VSS Dancer Roll Control panel . . . used on printing press re-winds for controlling tension and roll buildup directly from the paper web.

Complex control systems are easily designed using the Reliance V\*S Building Block Approach. Off-the-shelf components can be combined in wide variety to perform a diversity of precise control functions. The control of speed, torque and horsepower . . . the synchronization of motor speeds through feedback systems . . . and the accurate sensing devices that make precise control possible are an integral part of the V\*S system.

Pneumatic, hydraulic and electric sensing equipment—such as pressure gauges, photo electric cells, level indicators, or strain gauges can be tied directly to V\*S Drives. Many single-point and point-to-point numerical and digital systems have also been designed around these V\*S Drives.

### Fast—Stepless— Wide Speed Range

V\*S Drive components consist of a d-c. drive motor, packaged motor controls and operator's control station. Operation is from in-plant a-c circuits. You need only the drive motor at the machine . . . controls can be placed at any convenient location.

High response Reliance drive motors change speed over a wide range, smoothly and without steps. Selections are infinite. All-electric V\*S design permits inclusion of dynamic or regenerative braking for fast stopping.

A motor-generator set forms the nucleus of the motor control unit. Built-in controls regulate voltage and current in the system. You can get any required combination of speed, horsepower, torque and time characteristics.

### And New Super 'T' V\*S Drive Now Gives You More Power in 35% Less Space!

Through use of Class B insulation—better ventilation and new NEMA re-designed a-c. and d-c. machines, more power is packed into sharply reduced space. *And this V\*S Drive will take 100% overloads for one minute duration without failure.*

Reliance Super 'T' V\*S Drives can be custom designed to meet your specific needs.

Reliance Sales Engineers are always available to work with you. Call your nearest Reliance sales office or write for Bulletin D-2506.

D-1642-A

Product of the combined  
resources of  
Reliance Electric and  
Engineering Company and its  
Master and Reeves Divisions

**RELIANCE** ELECTRIC AND  
ENGINEERING CO.

DEPT. 288A2, CLEVELAND 17, OHIO

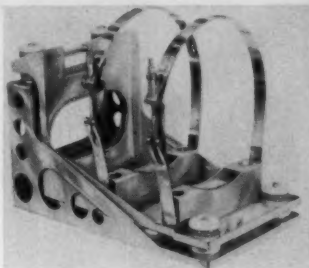
Canadian Division: Toronto, Ontario

Sales Offices and Distributors in Principal Cities



Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V\*S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.





for airborne equipment. Performance meets vibration and shock requirements as specified in MIL-E-5272A. Natural frequency is 16 cps with a vertical transmissibility of 4. Robinson Technical Products Inc., Teterboro Air Terminal, Teterboro, N. J.

Circle 761 on Page 19

### Coated Dacron

for diaphragm and gasket material

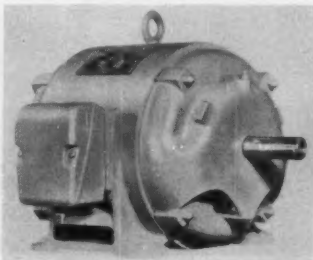
Kel-F coated dacron is intended primarily for use as diaphragm and gasket material in controls for aircraft, heating units, and other equipment operating at high temperatures. It can be supplied in various gages. In addition to its high-temperature performance, Kel-F has a high resistance to aliphatic and aromatic hydrocarbons, ozone, acids, and alkalis. Specifications for 0.012-in. Kel-F on dacron include tensile strength of 200/180 lb per in., and weight of 12½ oz per sq yd. Reeves Brothers Inc., 1071 Avenue of the Americas, New York 18, N. Y.

Circle 762 on Page 19

### Electric Motors

have extra vents to provide cool operation

Open drip-proof ac electric motors are furnished in 1 to 600 hp sizes. Vents below the terminal box provide intake of cooling air, in addi-



August 18, 1960

in the

## GRAY IRON spotlight

ENTRY  
GIFS  
DESIGN CONTEST

## Parts Re-evaluation by Clark Bros. Co. Leads to \$288 Saving

Leading manufacturers like Clark Bros. Co., who consistently re-evaluate their parts fabrication program, always analyse whether difficult-to-process parts can be made better, less expensively, with modern gray iron castings.

An example of the savings possible through an re-evaluation program are these adjustable guide vanes used on Clark centrifugal compressors. Formerly made of SAE 1045 steel, costly shaper and profile milling operations were necessary to complete the part. By using the ability of gray iron to be cast in complex shapes, Clark eliminated machining operations and saved \$18 on each of the 16 vanes.

Start a re-evaluation program in your own plant. Analyse the savings possible by making intricate parts of gray iron. Through cooperative effort with leading GIFS foundries, your progressive foundryman is in the ideal position to make the most worthwhile suggestions.

### FREE DIRECTORY OF PROGRESSIVE FOUNDRYMEN

Lists modern facilities, techniques and types of iron produced by leading gray iron foundries in your area. For a copy write: Dept. G, Gray Iron Founders' Society, Inc., National City-East Sixth Building, Cleveland 14, Ohio.



## Specify Modern

# GRAY IRON CASTINGS

Made by Informed Foundrymen!



Circle 565 on Page 19

257





## Zippertubing®

Instant Covering for All Applications!

Zippertubing, an economical on-the-job method of jacketing, is a flat tape, available in a wide range of materials, that has a patented extruded plastic track electronically welded to both edges. The tape or jacket is wrapped around the object to be covered so that the tracks engage, then "zip" shut. If permanent closure is required, a special sealant is provided that fuses the tracks together.



### GENERAL PURPOSE

Standard without overlap. Generally conforms to MIL-I-631C.

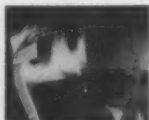


**MILITARY TYPE** with overlap Type 74 meets requirements of MIL-I-7444B. Type 63 meets MIL-I-631C. QPL certificates of conformance or test reports furnished on request.

**SHIELDED ZIPPERTUBING®** copper. These conductive metals are laminated to vinyl-impregnated Nylon or glass cloth. When zipped around wires, it provides immediate 100% coverage for grounding RF and UHF interference.

### THERMAZIP

Protects cables or pipes from high temperature exposures. Type ALAS utilizes aluminized asbestos cloth. Type ALSR utilizes silicon rubber-impregnated glass cloth.



**ZT PROTECHTORS®** NEW! Protective plastic covers with plastic zipper closure for splices and break-outs. Installation time is measured in minutes—not hours! Full range of sizes and colors.



**SPECIAL CONSULTATION** At your request, our Field Engineer will call or you can mail your design concept to us for evaluation and quotation. All requests confidential.

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**THE Zippertubing® CO**

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LOS ANGELES 14, CALIFORNIA  
PHONE MA 4-6664

Circle 566 on Page 19

## NEW PARTS AND MATERIALS

tion to vents in end bells. Other features include: Preloaded ball bearings fitted at both ends to give quiet running; large lubricant reservoir in bearing housing; pure aluminum rotor firmly mounted on high-tensile steel shaft and electronically balanced; terminal box that can be rotated readily to four different positions; and clearly marked leads making wiring easy. **Brook Motor Corp.**, 3302 W. Peterson Ave., Chicago 45, Ill.

Circle 763 on Page 19

### Surface Treatment

improves adhesion of paint to aluminum

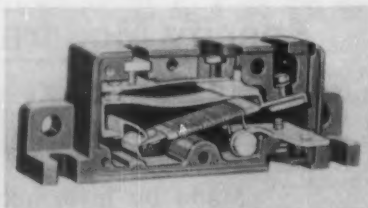
Chemlok 720 chemical surface treatment for aluminum greatly improves the adhesion of paints, lacquers, enamels, adhesives, and other coatings to the metal. With all air-dried lacquers and enamels, treatment produces adhesion unmatched by any previous treatment. With baked finishes, it gives improved results. Adhesion obtained is stronger than the coating applied. Highly resistant paints and coatings adhere until completely weathered away, assuring long-term protection. Coated aluminum parts can tolerate greater deformation during manufacture without injuring the coating. Treatment prevents undercutting and blistering of paint films, does not affect the base color of the aluminum, and can be used with all paints or clear coatings. **Hughson Chemical Co., Div., Lord Mfg. Co.**, Dept. 89, Erie, Pa.

Circle 764 on Page 19

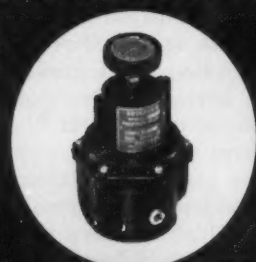
### Motor Protector

is rated from 0.1 to 15 amp

Precise calibration of automatic-reset circuit breaker or overload relay is provided by a co-ordination of bimetal element, heater coil, and infinite contact adjustment. Device



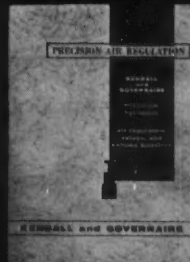
## PRESSURE REGULATORS?



SEND FOR NEW FREE CATALOG ON **KENDALL®**

and **GOVERNAIRE®**

Catalog gives performance and other data on 18 models of precision pneumatic pressure regulators. (pipe sizes 1/4" to 1/2" NPT)

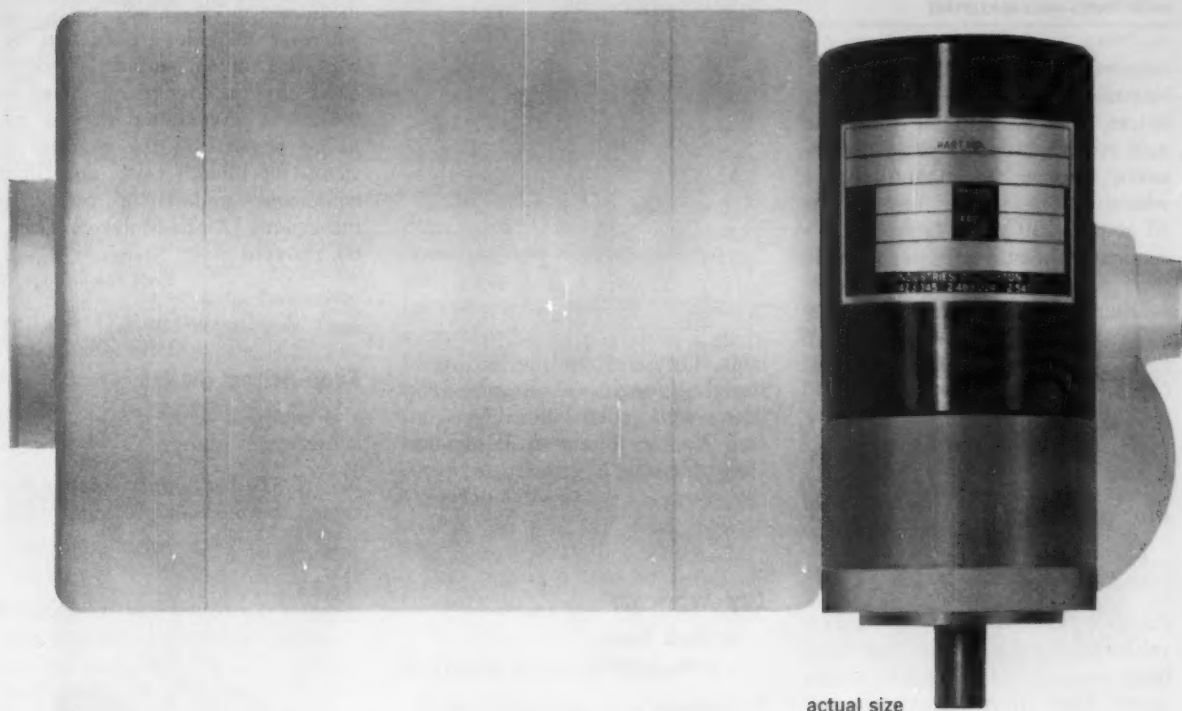


**STRATOS®**

A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION  
**INDUSTRIAL PRODUCTS BRANCH**  
West Babylon, L. I., N. Y.

Circle 567 on Page 19

MACHINE DESIGN



## GEARMOTORS $\frac{3}{4}$ SMALLER

The Globe a.c. gearmotor you see superimposed against a conventional right-angle gearmotor will give your product major advantages: Globe's version is much smaller than the big style, is interchangeable with slight mounting changes, produces the same torque, and should run 5 to 7 times as long without maintenance, even with high inertia loads. Study the picture above with **your** application in mind.

Furthermore, Globe gives you a choice of 101 **standard** planetary gear ratios, and any special ratios or other features you need. The Globe gearmotor is competitive in cost even though it meets military specifications. If you don't have rigid environmental requirements Globe can furnish a commercial version in production quantities at a saving to you. If you design with induction or hysteresis synchronous gearmotors—investigate now.

Globe has available for **immediate** shipment prototypes of the Type FC, 115v. a.c., 60 cycle synchronous motor in the following gear ratios: 352.6 to 1 (10.2 rpm, 160 oz. in. out), and 27.94 to 1 (64.4 rpm., 19 oz. in. out). Other variations, including d.c., about 4 week delivery. Please request Bulletin FCB from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

**GLOBE**

**GLOBE INDUSTRIES, INC.**

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS,  
TIMERS, STEPPERS, BLOWERS, FANS, MOTORIZED DEVICES

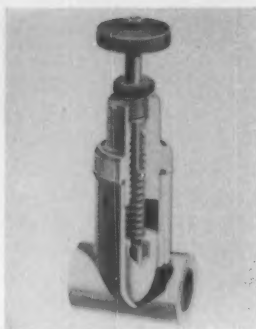
responds to rising temperature and excessive current draw of the motor. It can be built into the motor or used remote attached either to the motor surface or mounted elsewhere. Ratings range from 0.1 to 15 amp to 230 v ac. Typical applications are motor-driven equipment such as household appliances, air conditioners, refrigerators, fans, and pumps that have fhp motors. E-T-A Products Co. of America, 6284 N. Cicero Ave., Chicago 46, Ill.

Circle 765 on Page 19

### Plastic Valves

handle solvents  
and acids

Polypropylene throttleable gate valves are light in weight and have high strength and chemical resistance. They resist most solvents, greases, oils, and the majority of common acids at temperatures to 185 F. Valves are available from stock in sizes from 1/2 to 2 in. with socket-weld, flanged, or screwed



ends. They combine the features of straight-through, no-pressure-drop flow, with close throttling control. Vanton Pump & Equipment Corp., Hillside, N. J.

Circle 766 on Page 19

### Dry Lubricant

in stock form  
is resin bonded

Extreme-pressure molybdenum disulfide dry lubricant in stick form, resin bonded for high strength, permits easy application of a lubricating film to cutting and shaping tools, sliding areas of small and

medium-size machine parts, or wherever metallic dry friction occurs on sliding surfaces. Because of its physical strength, stick can be formed in any desired size for use as an element in the bearings of small machines, ways, and light equipment undergoing oscillating movements. Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.

Circle 767 on Page 19

### Snap-Action Switch

is equipped with  
overtravel plunger

No. 14-324 heavy-duty, snap-action switch is suited for precision indus-



Mr. W. C. Guent, Jr. of Master Etching Company, Wyncote, Pa. says:

**"General Electric's Polydyne® Drive Adds Three Important Sales Features To Our Product"**

Accurate speed control, wide speed range and fast speed-changing capabilities mean time savings and better printing plates for users of Master Etching Machine Company's powderless etcher.

These features, along with compact size, low maintenance and operating simplicity, have made Polydyne drives the EXCLUSIVE choice of Master Etching Company for the mechanical adjustable speed drive on their model M-32 etcher.

With Polydyne drives you can get a wide range of process speeds and adapt machine speed to meet requirements of different operations with fewer machines—straight from a-c power.

Why not investigate the advantages of using a Polydyne drive on your equipment? Polydyne

drives are available from 1/4 to 25 hp with output speeds from 4200 to 5 rpm in a wide variety of configurations and enclosures.

For more information, contact your G-E Apparatus Sales Office or Distributor, or write for Bulletin GEA-6806, Section 854-04, General Electric Co., Schenectady 5, N. Y.

*Progress Is Our Most Important Product*

**GENERAL  ELECTRIC**

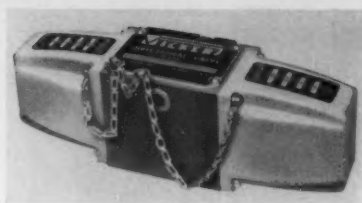
trial and machine tool applications. Equipped with an overtravel plunger, switch offers a 20-amp rating, long mechanical life, and exceptional shock and vibration resistance. Double-break design dissipates arc and heat energy in two places. Rugged plunger provides 1/4-in. overtravel for in-line switch operation. Unit is designed for panel mounting, but standard mounting holes allow side or gang mounting on screws. **Licon Div., Illinois Tool Works, 6606 W. Dakin St., Chicago 34, Ill.**

Circle 768 on Page 19

### Control Valve

incorporates improved air-cooled solenoids

Solenoid-operated, four-way directional control valve offers compactness and versatility for many directional control requirements of hydraulic machinery. Valve has a nominal rating of 8 gpm and handles flows up to 12 gpm without malfunction. Subplates are furnished with 3/8-in. ports, or with 1/2-in.



ports to take advantage of larger flows. Maximum recommended operating pressure is 3000 psi. Valve incorporates improved air-cooled solenoids which are retained in their cover rather than being mounted separately. In addition to quiet and cool operation, shockfree performance is assured through superior cushioning. Solenoids are rated for 115-v, 50 or 60-cycle ac service. **Vickers Inc. Div., Sperry Rand Corp., Detroit 32, Mich.**

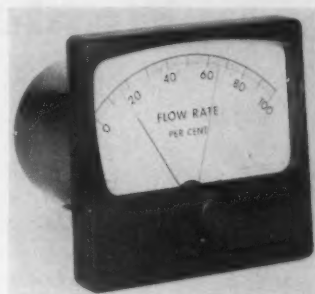
Circle 769 on Page 19

### Maximum-Reading Meter

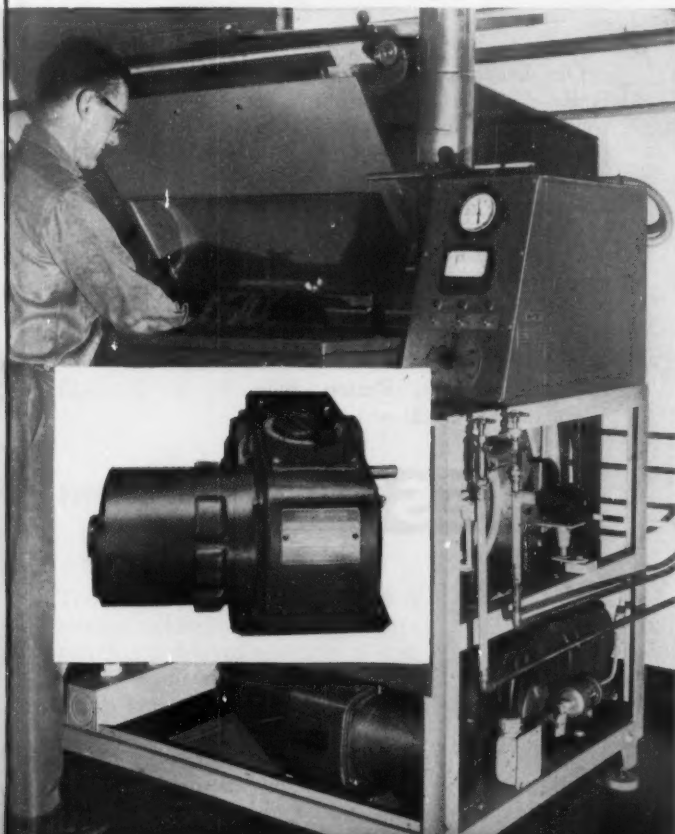
shows highest level reached by electrical signal

Maximum-reading meter combines a meter-relay movement and special circuitry to show the highest

level reached by an electrical signal. Until reset, the adjustable pointer of the meter remains at the maximum signal reached over any period of time, and the other pointer provides continuous signal indication. Any variable that can be expressed as an electrical signal can be measured with the meter; in most cases a direct, unamplified signal is used. Maximum reading meter is available in standard sensitivity



ranges of 0-10 ma to 0-50 amp, or 0-5 mv to 0-500 v, ac or dc. Case styles are 2 1/2-in. round, sealed models, and 4 1/2-in. rectangular, black bakelite models. Circuit components



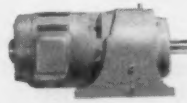
Compact, low maintenance General Electric Polydyne drive (insert) gives the Master Etching Machine a wide speed range and accurate speed control—features that build strong customer preference.

### General Electric Offers a Complete Line of Low-speed Drives 1/8 to 200 HP

Select from G.E.'s PLUS LINE of compact mechanical power transmission equipment! A full range of ratings is available—many directly from stock.



General Electric Polydyne Drive



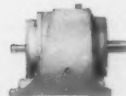
Integral-type Gear Motor



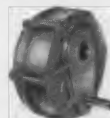
Right-angle Shaft Gear Motor



All-motor Gear Motor



Footed Speed Reducer



Shaft-mounted Speed Reducer

General Electric would like to help solve your specialty mechanical power transmission problems.

For further information write:

**Mr. C. R. Andersen, Mgr. Product Planning, Gear Motor & Transmission Components Department, 845 E. 25th Street, General Electric Co., Paterson, N. J.**

Member of American Gear Manufacturers' Association

**GENERAL  ELECTRIC**

Circle 569 on Page 19



# Wanted: Engineers

*with an interest in writing*

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested

in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

**MACHINE DESIGN**

are mounted in a barrel-type housing in back of the meter. Assembly Products Inc., Chesterland, Ohio.

Circle 770 on Page 19

### Pressure Controls

for application in many fields

Series of pressure controls offers a wide range of application in many fields. All parts of the control in direct contact with the pressure medium are 316 stainless steel. Bourdon-tube power element and bottom pressure connection are of 316 stainless steel (welded). Internal mechanism is nickel plated to pre-



vent corrosion. Unit has outside adjustments for easy setting of operating points. Visible calibrator tells at a glance the exact operating points at which control is set. Hermetically sealed mercury contact, also visible, provides a quick means of determining whether circuit is on or off. Control is available in general-purpose case NEMA 1, weather-proof NEMA 2, 3, 4, explosionproof NEMA 7, 9, 9A. Mercoind Corp., 4201 Belmont Ave., Chicago 41, Ill.

Circle 771 on Page 19

### Synthetic-Rubber Base Adhesive

provides temperature and water-resistant bonds

Translucent, amber-colored adhesive retains tackiness for several hours, permitting delayed assembly of trim fabric, insulation, and similar materials to metals or fiber board. Rez-N-Glue 164 is particularly useful for single-surface application and temporary process bonding, eliminates unsightly residues that result from use of red or black adhesives. Bonds form quickly, are tough, and

**It's about time**

Whether an interval is a month or a microsecond, you can measure it, divide it, record it, or use it for control with an A. W. Haydon Company custom-designed or standard timer. Every type, every size, every class...timing motors, time delay relays, interval timers, repeat cycle timers...you name it, we make it. If you ever have a specific timing problem, the least you can do for yourself is get our literature. In fact, why not send for our Bulletin on the 14100 Series DC Motor (above) right now. This two-ounce sub-miniature DC Timing Motor is less than 1" in diameter, 1 1/8" long. Used to drive a miniature tape recorder in the Vanguard II weather satellite (expected to remain in orbit for 200 years), it represents the high capability of The A. W. Haydon Company in timing devices.

**AWH HAYDON**  
THE COMPANY  
223 North Elm St., Waterbury, Connecticut

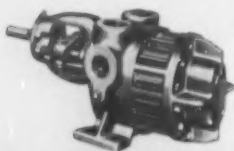
# WHATEVER YOUR REQUIREMENTS FOR ROTARY PUMPS, THERE'S A ROPER TO DO THE JOB

## Series T .3 to 55 GPM Choice of 192 Models

Pump and motor units . . . pump serves as end bell of motor. Require minimum space . . . easily installed . . . no coupling required . . . mount in any position. Each unit approximately same size as NEMA motor of HP required for driving. Open drip proof or totally enclosed motors; single or three phase as required.



## ROPER ROTARY PUMPS



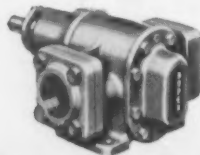
## Series F 1 to 300 GPM Pressures to 300 PSI

Feature helical steel pumping gears, hardened steel shafts, bronze flange-type bearings. 4-port design with 8 optional piping arrangements (4 for CW and 4 for CCW rotation) solves installation problems. With or without built-in relief valve in either mechanical seal or packed box construction.

## ROPER ROTARY PUMPS

## Series K ¼ to 50 GPM Pressures to 150 PSI

Extremely compact in all sizes. Helical pumping gears are hardened steel, with steel shafts and bronze bearings. Sizes 10 through 50 GPM have patented venturi suction and discharge principle for smooth flow and quiet operation. With or without built-in relief valve; packed box or mechanical seal.



## ROPER ROTARY PUMPS



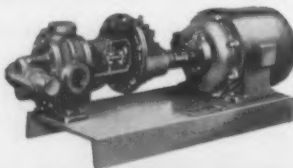
## Series H 5 to 75 GPM Pressures to 1000 PSI

Designed to operate at direct motor speeds. Used for all types of hydraulic mechanisms where high pressures are required. Hardened steel spur gears for maximum efficiency, and heavy duty roller bearings and bronze wear plates for long life service. Mechanical seal or packed box.

## ROPER ROTARY PUMPS

## Series 3600 40 to 300 GPM Pressures to 100 PSI

Handle thick or thin liquids at slow speeds. Operate in either direction. Hardened iron pumping gears, hardened steel shafts, heavy duty bronze sleeve bearings. Mechanical seal or packed box. Series includes tank truck pumps as well as single motor driven units with gear reduction.



## ROPER ROTARY PUMPS

Send for  
"How to Solve Pumping Problems"

**Roper Hydraulics, Inc.**

Manufacturers of Standard, Special and Custom Pumps for All Industries

COMMERCE,  
GEORGIA

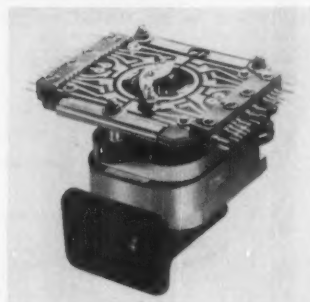
## NEW PARTS AND MATERIALS

resistant to heat, cold, and water. Adhesive is applied by brush-coating clean, greasefree surfaces of both sections. Sections can be bonded immediately or at any time within 24 hr. Adequate bonds of single-surface coating can be obtained immediately or within 20 min. Schwartz Chemical Co. Inc., 50-01 Second St., Long Island City 1, N. Y.

Circle 772 on Page 19

## Stepping Switch

for operation to  
240 steps per sec



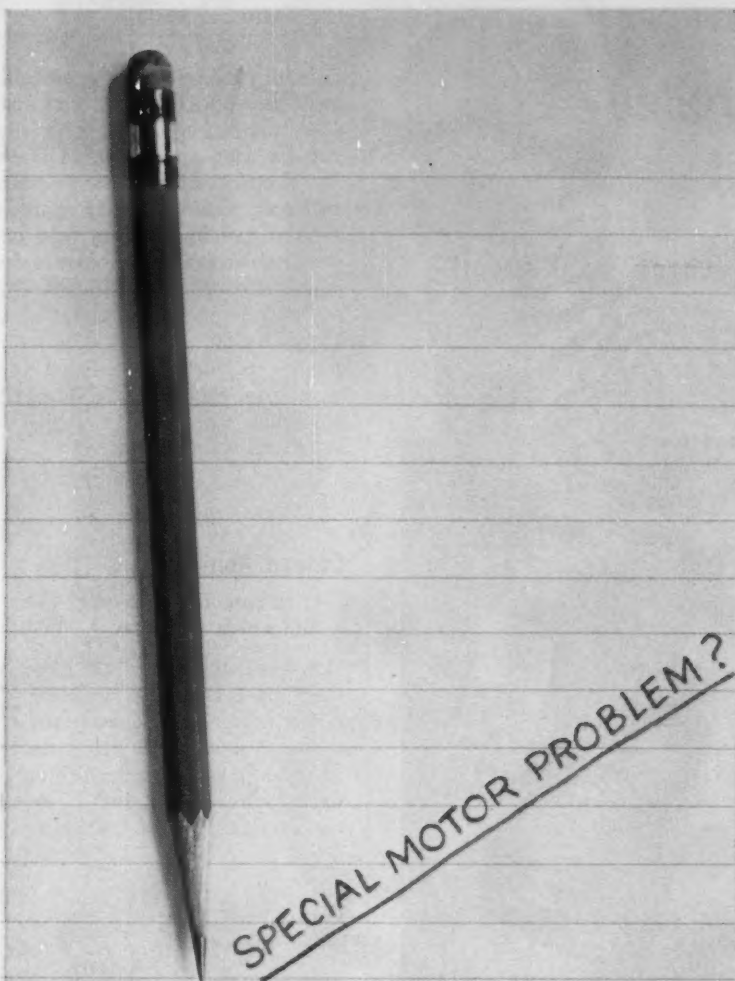
Electromagnetic stepping switch, consisting of a high-speed stepping motor and printed-circuit switch decks, provides true digital behavior to 240 steps or 12 rps. Series 9C Cycloswitch has no ratchets, pawls, mechanical stops, or brushes, and has an extremely long operating life. Switch stops instantly at any predetermined position on the switch deck. Flush-printed switch decks are available in various combinations to meet specific needs. Operating power ranges from 1/3 to 40 w, depending on speed and the number of brushes. Current-carrying capacity is 1.5 amp at 250 v dc. Sigma Instruments Inc., 42 Pearl St., South Braintree 85, Mass.

Circle 773 on Page 19

## Spaghetti Tubing

resists all inorganic  
corrosive liquids

Penntube III spaghetti tubing and monofilament is extruded from a tough, clear, modified trifluoro-chloroethylene polymer with the thermal and chemical stability of fluorocarbons and advantages of lower cost, transparency, and heat



*A sharp pencil is all you need...*

*Got your special motor application problem down and send it to Lamb Electric...we'll do the thinking, design and manufacture. You get the right motor, "custom-tailored", and mass produced at the most favorable cost...*

PERSONALIZED  
MOTOR  
CONFERENCE



**Lamb Electric**

SPECIAL APPLICATION  
FRACTIONAL HORSEPOWER MOTORS

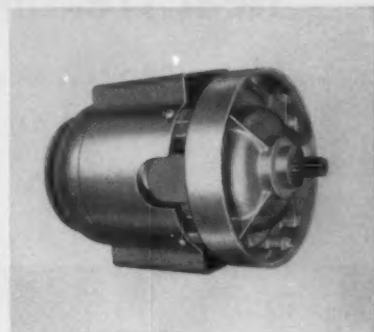
THE LAMB ELECTRIC COMPANY • KENT, OHIO

A Division of American Machine and Metals, Inc.

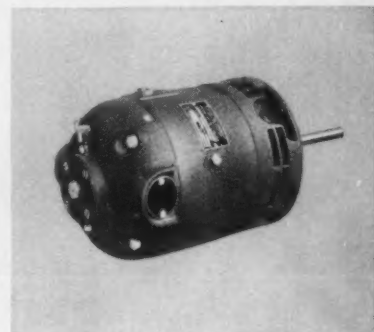
In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

Divisions of American Machine and Metals, Inc., New York 7, New York TROY LAUNDRY MACHINERY • RIEHLE TESTING MACHINES • DE BOTNEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS • NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC CO. • HUNTER SPRING CO. • GLASER-STEERS CORP.

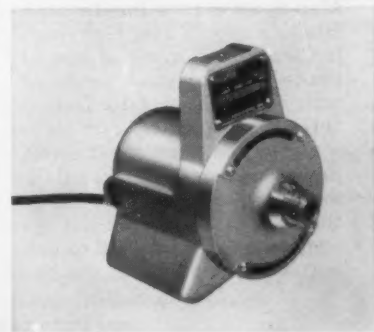
## **Special Application Fractional Horsepower Motors**



Explosion-proof motor, totally enclosed and fan-cooled. Excellent for high pressure grease guns. Frame:  $3\frac{11}{16} \times 2\frac{1}{4}$ . **Lamb Electric Company, Kent, Ohio.**



For industrial vacuum cleaners, colloid mills, hoists, etc. Heavy duty motor,  $6 \times 2\frac{1}{2}$  frame. **Lamb Electric Company, Kent, Ohio**

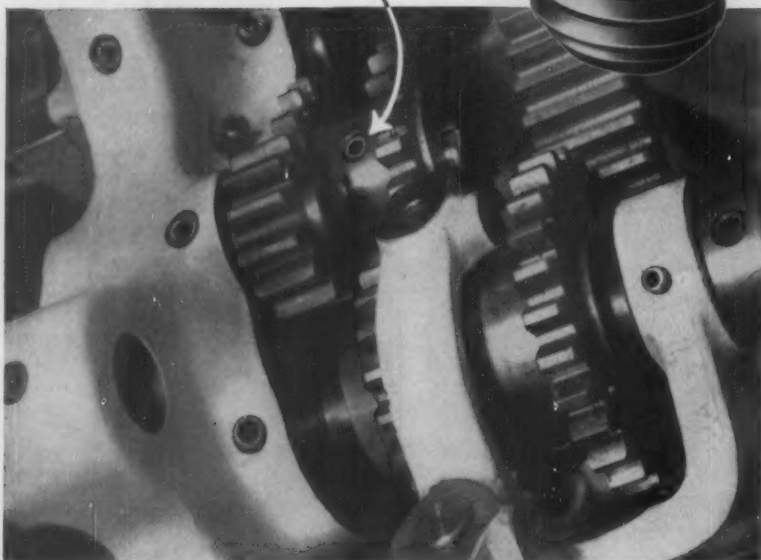


Heavy duty industrial quality motor for portable concrete vibrator. Frame:  $4\frac{3}{8} \times 2\frac{1}{2}$ . **Lamb Electric Company, Kent, Ohio.**



## Dimensionally Controlled Heat Treatment

gives Mac-it screws  
extra strength  
here



Speed, vibration, stress are tough operating conditions that extra strong, extra resilient Mac-it set screws handle with amazing ease. These high quality screws are made of special pre-tested alloy steel, produced with clean, sharp, fully formed threads and points.

Controlled heat treatments, based on material, physical dimensions and end-use, mean that Mac-it set screws resist up-setting of the points and rounding out or splitting of the hex

sockets. This guarantees screws that can be set and re-set again and again with confidence. They are available with cup, flat, cone, oval and dog points so that you can select exactly the style you need.

The interest, skill and care of Mac-it specialists is your assurance that every Mac-it screw will give you the service you want—every time. That's why we say, choose Mac-its . . . they hold tight in tight places!

Buy by name from your distributor—buy Mac-it.

NEW SPECIFICATION SHEET listing new 1960 Series Industry Dimension Standards for socket head cap screws. Write for your free copy.

Mac-it Parts Co., Dept. 21, Lancaster, Pa.



### MAC-IT ALLOY STEEL SCREWS

#### NEW PARTS AND MATERIALS

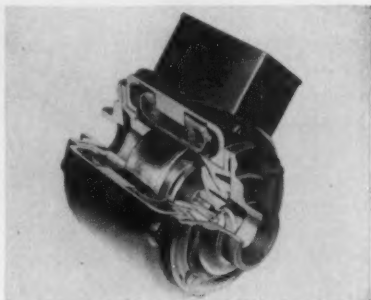
sealability. Available in monofilament down to 0.008 in. and spaghetti tubing in AMS 3648 sizes, it finds wide application in chemical, electrical, and electronic design problems where ordinary materials are not suitable, and in other applications where it can often replace the services of stainless steel. Tubing is highly impermeable, resists all inorganic corrosive liquids including oxidizing acids, and most organic solvents. **Pennsylvania Fluorocarbon Co. Inc.**, 1115 N. 38th St., Philadelphia 4, Pa.

Circle 774 on Page 19

#### Canned Pump

is leakproof, noiseless  
and resists vibration

Low-head, high-volume, 1/6 to 3/4-hp pump is leakproof, noiseless, and resists vibration. It measures 8 3/4 x 8 1/4 in. and weighs approximately 33 lb. Pump is made in stainless steels, Hastelloy B or C, bronze, cast iron, or Monel. Line is sup-



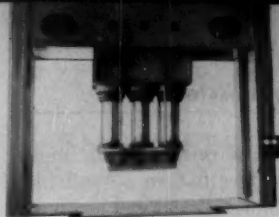
ported in any position. It has only one moving part, the rotor-impeller, which is directly driven by currents generated by the stator, located in the center of the electric motor. There are two friction points only, the front and rear bearings, which are lubricated by the liquid being pumped—no seals or packing are necessary. **Corley Co. Inc.**, Boonton, N. J.

Circle 775 on Page 19

#### Two-Way Solenoid Valve

has only three moving parts

Two-way, general-purpose solenoid valve has 1-in. pipe connections and only three operating parts. Having a forged brass body and bonnet,



You can depend on the uniform structure and properties of Meehanite nodular whether the casting weighs  $\frac{1}{2}$  ounce as pictured below or many hundreds of pounds. Photograph above shows a 1500 ton Hydraulic press with Meehanite rams.



**in nodular iron . .**

**soundness can be controlled**

## Meehanite foundries have the "know-how" and experience

There is nothing new about nodular or ductile cast iron, but the problem is that not every foundry has the metallurgical know-how and facilities to produce castings that live up to published claims.

When you purchase nodular iron from a Meehanite foundry you can always be sure of getting dependable castings that possess the desired engineering advantages — *high strength, ductility, toughness.*

The consistent, high quality of Meehanite castings is achieved by a "proven" manufacturing procedure used by Meehanite foundries throughout the world. Meehanite foundries have

over a quarter of a century of experience in the manipulation and use of the essential processing materials needed to convert the graphite in cast iron from the flake form into the nodular.

Put this experience to work for you. Avoid the risk of costly defects. Seven different "S" types of Meehanite nodular are available and there is a nearby Meehanite foundry ready to serve your needs.

For more facts about Meehanite Nodular Iron write for your FREE copy of our new bulletin No. 47. Write today to Meehanite Metal Corp., 714 North Ave., New Rochelle, N.Y.

## MEEHANITE METAL

The American Laundry Machinery Co.,  
Rochester, N. Y.  
Atlas Foundry Co., Detroit, Mich.  
Banner Iron Works, St. Louis, Mo.  
Barnett Foundry & Machine Co.,  
Irvington, N. J.  
Casting Service Corp., LaPorte, Indiana  
and Bridgman, Michigan  
Centrifugally Cast Products Div., The  
Shenango Furnace Co., Dover, Ohio  
Crawford & Doherty Foundry Co.,  
Portland, Ore.  
Dayton Casting Co., Dayton, Ohio  
Empire Foundry Co., Tulsa, Okla.  
and Bonham, Texas  
Florence Pipe Foundry & Machine Co.,  
Florence, N. J.

Fulton Foundry & Machine Co., Inc.,  
Cleveland, Ohio  
General Foundry & Mfg., Flint, Mich.  
Georgia Iron Works, Augusta, Ga.  
Greenlee Foundries, Inc., Chicago, Ill.  
Hamilton Foundry Inc., Hamilton, Ohio  
Johnstone Foundries, Inc., Grove City, Pa.  
Kanawha Manufacturing Co.,  
Charleston, W. Va.  
Kennedy Van Saun Mfg. & Eng. Corp.,  
Danville, Pa.  
Lincoln Foundry Corp., Los Angeles, Calif.  
Oil City Iron Works, Corsicana, Texas  
Palmyra Foundry Co., Inc., Palmyra, N. J.

The Henry Perkins Co., Bridgewater, Mass.  
Pohlman Foundry Co., Inc., Buffalo, N. Y.  
Rosedale Foundry & Machine Co.,  
Pittsburgh, Pa.  
Ross-Meehan Foundries, Chattanooga, Tenn.  
Sonith Foundries of FMC, Indianapolis, Ind.  
Standard Foundry Co., Worcester, Mass.  
The Stearns-Roger Mfg. Co., Denver, Colo.  
Vulcan Foundry Co., Oakland, Calif.  
Washington Iron Works, Seattle, Wash.  
Darr-Oliver-Long, Ltd., Orillia, Ontario  
Hartley Foundry Div., London Concrete  
Machinery Co., Ltd., Brantford, Ontario  
Otis Elevator Co., Ltd., Hamilton, Ontario

**MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK**

# BHEW

## HYDRAULIC CYLINDERS FOR TOP ON-THE-JOB RESULTS

If you insist upon top performance on-the-job, then always demand B-H-E-W products. Only B-H-E-W offers basic designs and trained specialists to adapt these quality design techniques to suit your specific application. With B-H-E-W working for you, production economies, production efficiency and quality products are your end results!

THIS IS B-H-E-W's "DUAL PILOT" CHECK VALVE. It insures positive piston rod lock in any position when the directional control valve is in neutral. You know the rod will not drift. This simplifies hydraulic line circuitry, eliminates separate pilot operated check valves, connections and lines. Your on-the-job efficiency is highly improved when you use B-H-E-W Hydraulic Cylinders!

DISCUSS YOUR DESIGN AND APPLICATION PROBLEMS WITH US!



WRITE TODAY for free Hydraulic Cylinder Engineering Reference data, 78 dimensional basic designs for general purpose and special double- and single-acting cylinders. SAVE TIME!



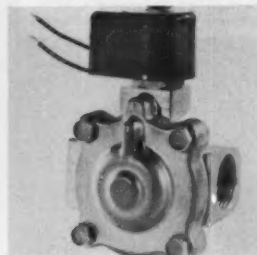
INTEGRITY • CHARACTER • QUALITY

**BENTON HARBOR ENGINEERING WORKS, INC.**

622 Langley Avenue • St. Joseph, Michigan

## NEW PARTS AND MATERIALS

valve measures only 5 $\frac{7}{8}$  in. high and 3 $\frac{3}{4}$  in. face-to-face. Available for either normally closed or normally open operation, valve can be mounted in any position. Tight sealing, it handles air, gas, water,



light oil, and other noncorrosive liquids or gases at pressures from 5 to 125 psi. Three operating parts consist of a Buna-N diaphragm, stainless-steel diaphragm spring, and stainless-steel solenoid core. Requiring only 10.5 w ac or 10 w dc to operate, valve can be provided in any voltage to 550 v ac, 60 cycles, or 250 v dc. Automatic Switch Co., Florham Park, N. J.

Circle 776 on Page 19

## Vinyl-Clad Metal

laminate can be worked with conventional equipment

Clad-Rex 102 combines in one product the ultimate properties of the metal with the optimum characteristics of vinyl. System produces a vinyl-metal laminate that can be worked with conventional metal-forming equipment to severe configurations, and permits exposure to elevated temperatures without delamination. Forming requires no consideration beyond that normally given to sheet metal. Material can be formed as deep as 9:1 ratios. It can be pinch-trimmed or model-trimmed without having any adverse effect on the vinyl. Drawn and trimmed material can be exposed to elevated temperatures for extended periods of time without the necessity of any previous post curing or annealing between forming and trimming. Material can be supplied in most decorative designs of vinyl, in outdoor, weatherable vinyls, and in stain-resistant vinyl. Clad-Rex Div., Simoniz Co., 11500 King St., Franklin Park, Ill.

Circle 777 on Page 19



## ENGINEERING DEPARTMENT EQUIPMENT

### **Illuminated Magnifier**

has full corrected  
3X magnification

Illuminated magnifier rests securely on any flat surface, allowing complete freedom of both hands. Features of the instrument include full corrected 3X magnification and a wide field of view. Even illumination covers the entire area under



examination. Magnifier has an attractive gray finish and features lightweight, durable construction. It measures 5 x 3 x 3 1/4 in., and is available in battery-operated or 115-v model. Bausch & Lomb Inc., Rochester 2, N. Y.

Circle 778 on Page 19

### **Drafting Machine**

is balanced for use  
at any board angle

Tracmaster 60 drafting machine is automatically balanced for use at any board angle and on all-size boards without adjustment. Ability of the unit to lock to a point in one elevation and carry this point vertically or horizontally to another view is a great advantage in original design and assembly drawing work. It is also recommended for accurate layouts, full scale blow-ups, and long-line drawings. Rigid beam-rail construction in both horizontal and vertical beam rails provides essential rigidity and strength for true tracking, straight line, and parallel accuracy. Guide rail is in the center of the beam for maximum sta-

# H & K

suppliers of quality  
perforated materials  
to American industry  
since 1883

Complete 156 page catalog on request

THE  
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New York 6, New York





# NEW QUICK-CHANGE "PLUG-IN" TIMERS

## REMOVE AND REPLACE IN SECONDS

The new plug-in feature of the Atcotrol Reset Dial Timer permits fast, easy timer removal and replacement... keeps industrial process "down time" to a minimum because complete timer changes can be made instantly.

These Series 305 miniaturized timers control up to six individual load circuits, AC or DC, within variable timed intervals or sequences, with high repetitive accuracy. Able to perform 145 different circuit functions, they reset in less than 1/10 second, either stop or reset upon power interruption. As with all Series 305 timers, the plug-in model offers exclusive one-hole mounting.

### PLUG-IN CONVERSION KIT

Standard Series 305 timers will continue to be made available for applications where the plug-in feature is not desired. These timers and those already installed, however, can easily be converted in the field to plug-in models.

For complete specification and a schedule of prices, contact your nearest ATC sales office. Request Bulletin N-141.

## AUTOMATIC TIMING & CONTROLS, INC. KING OF PRUSSIA, PENNSYLVANIA

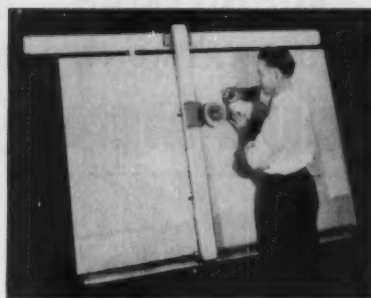
A Subsidiary of American Manufacturing Company, Inc.

ATC, Div of Interprovincial Safety Industries, Ltd., 5485 Notre Dame St., West, Montreal 30, Quebec.

WHEN INSTALLED, the plug-in model's plated, non-corrosive hex sockets engage plated banana plugs in a tubular case for positive spring pressure contact. A keyed guide pin aligns timer in its tubular enclosure, protrudes through rear to accept a snap-in cotter pin clip, assuring continuous full-contact engagement. This safety clip must be removed before unplugging a "hot" timer, so that only authorized persons can make timer replacements. An optional front-mounting clamp is available for installation where rear accessibility cannot be accomplished.



### ENGINEERING DEPT. EQUIPMENT



bility and protection against accidental damage. It is fully enclosed by an endless nylon tape, protecting rails from dust and erasures. Less than 8 oz of pressure move the protractor to any position on the board at any board angle. New protractor height adjustment, so that only the scales touch the drawing, reduces board friction. Mounting brackets fit any drawing board without adjustment and automatically set proper height of Y-beam. Units are available for all standard-size boards and on special order for boards of any length and up to 96 in. side. Left-hand machines are also available. Universal Drafting Machine Corp., 7960 Lorain Ave., Cleveland 2, Ohio.

Circle 779 on Page 19

### Direct-Writing Oscillograph

is portable,  
single-channel unit

Self-contained, single-channel, direct-writing oscillograph is available in two models—Model 299 with general-purpose dc amplification, and Model 301 with an ac carrier amplifier. Both models provide readout in clear, inkless traces on rectangular-co-ordinate 40-division charts, and can be used frequently and easily. Maximum sensitivity for Model 299 is 10 mv per chart division, and frequency response is dc to 100 cps within 3 db

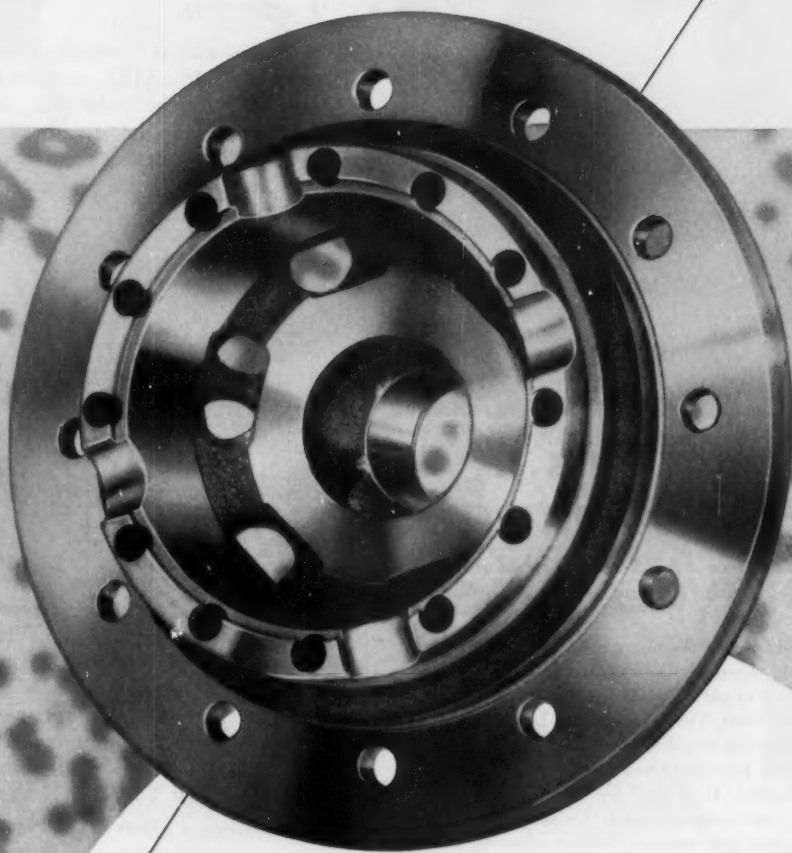


s your problem

# machinability?

## NATIONAL HTM CASTINGS

are the answer



There are many reasons for specifying HTM (Pearlitic Malleable) castings for your product. One is *machinability* of 70-90 percent (B1112 steel = 100).

But there are many other equally valid reasons. High ultimate strength . . . extreme wear resistance under heavy loads and high speeds . . . non-seizing qualities . . . air or liquid quenching . . . ability to be smooth-finished.

So when you're looking over the materials field, don't overlook the advantages of HTM castings. For HTM metal can be cast by either the shell mold, CO<sub>2</sub>, or green sand methods. This means production costs tumble . . . performance and saleability of your product go up.

### Important Physical Properties

Brinell	163 to 302*
Yield, psi	48,000 to 85,000*
Ultimate, psi	70,000 to 110,000*
Elongation, %	7 to 2*

\*Depending upon grade



**NATIONAL MALLEABLE CASTINGS COMPANY**

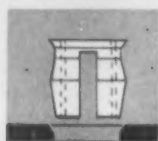
Established 1868

Cleveland 6, Ohio

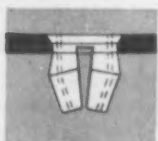
The nation's largest independent producer of malleable and pearlitic malleable

Circle 579 on Page 19

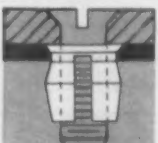
member  
MALLEABLE  
CASTINGS COUNCIL  
A-6812



Into a countersunk hole, punched or drilled, of proper size.



Merely press a T Series BANC-LOK. Sharp edge of slot anchors itself to prevent turning.



Complete assembly with final locking action by inserting screw—the slotted end expands making the assembly vibration proof. Banc-Lok threads are reusable indefinitely without stripping.

Patented & Patents Pending

## DO JUST THIS... with a BANC-LOK INSERT

*And You Have a Self-Locking Tapped Hole for Flush Fastening—No Costly Tapping—No Special Tools*

BANC-LOK, the one-piece, self-locking insert, with reusable threads, eliminates costly tapping operations—is so quick and easy to apply that it slashes assembly costs. The T series Banc-Lok tapped hole is designed for any sheet metal fastening where non-strippable, reusable threads, with sure locking action are required. It is ideal for such applications as assembling electronic chassis, fastening hardware to metal doors and windows, locking adjusting screws and mounting instruments.

Banc-Lok tapped holes are available in a variety of designs (flat head, step type and spacers) and in a wide range of grip lengths to accommodate varying material thicknesses. For full details on sizes, types and application, send for the new Banc-Lok catalog, write:

## BOOTS CORPORATION

NEWTOWN TURNPIKE • NORWALK, CONN.  
Victor 7-2727 • TWX NWLK 95-U

## BOOTS-WESTERN

432 NORTH LAKE AVE., • PASADENA, CALIF.  
MU 1-6679 • TWX PASA CAL 7255-U

Circle 580 on Page 19

## ENGINEERING DEPT. EQUIPMENT

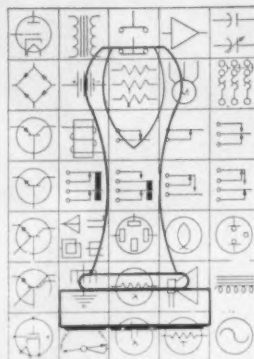
at 10 division peak-to-peak amplitudes. Model 301, for ac recording of transducer output levels, contains an oscillator, high-gain carrier amplifier, and phase-sensitive demodulator. All circuitry is transistorized on this unit. Switch-selected chart speeds of 5 and 50 mm per sec are available on both models. **Industrial Div., Sanborn Co., 175 Wyman St., Waltham 54, Mass.**

Circle 780 on Page 19

## Technical Stamps

for many fields  
of engineering

New stamps utilize standards established by ASME, ASEE, and ASA. There are stamps available for many fields ready for distribution. They eliminate detail work, and can be used for layout and design



work or as finished drawing reproduced by blueprinting, Ozalid, Verifax, or other copy methods. All circular and rectangular symbols are about  $\frac{3}{4}$  in. in size. **Technical Stamp Div., Paper Equipment Distributing Co., P. O. Box 90, Prince St. Station, New York 12, N. Y.**

Circle 781 on Page 19

## Vacuum Oven

for high-temperature use

Super-Temp Duo-Vac oven has a temperature range from room to 260 C (500 F) within an 11-in. diam x 12-in. deep stainless-steel vacuum chamber. Unit was designed specifically for processing and testing electronic components where high temperatures under vacuum often are essential. Radiant-heating elements are completely enclosed with no exposed-wire heat-

MACHINE DESIGN





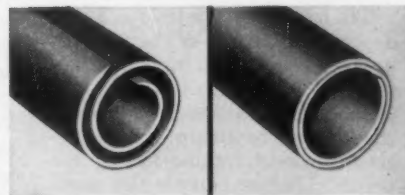
## Bundy can mass-fabricate practically anything

... with Bundyweld®—double-walled steel tubing that is adaptable to a whole host of applications.

WHATEVER your tubing problems, the Bundy man awaits your call. That's because tubing problems are Bundy's business, and Bundy engineers—with years of tubing experience—can often come up with a design angle that'll save you time and money.

But the Bundy service doesn't end there! Specially designed Bundy machines take over the mass-fabrication of these parts in unlimited quantity. And to meet rigid specifications, we use Bundyweld—the original double-walled steel tubing—the safety standard in small diameter tubing. Thinner-walled Bundyweld is stronger and gives you higher bursting and fatigue strengths. Meets ASTM-254 and Government Spec. MIL-T-3520, Type III.

Why not bring your tubing troubles to Bundy? See Sweet's Product Design File le/Bu . . . or write Bundy Tubing Company, Detroit 14, Michigan.



Bundyweld is the original tubing double-walled from a single copper-plated steel strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to 3/4" O.D.

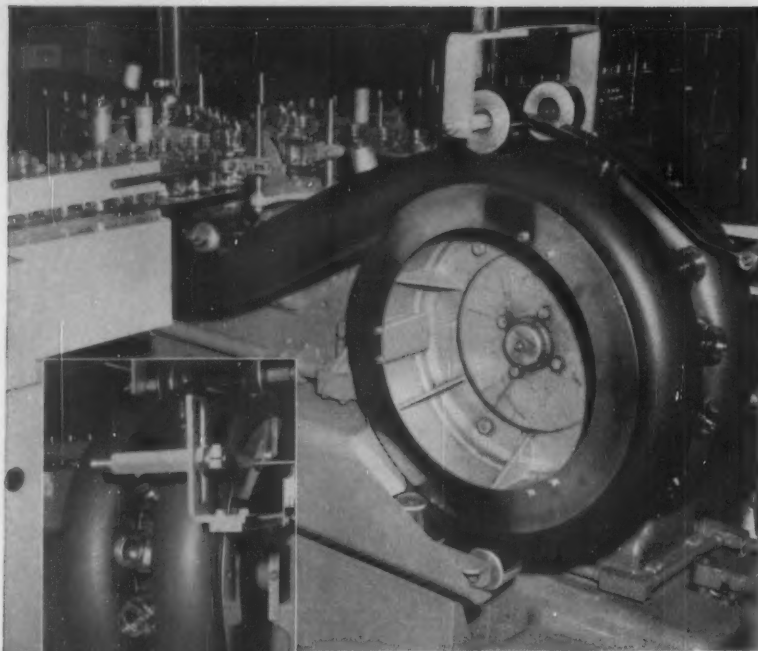
*There's no substitute for the original Bundyweld Tubing*

# **BUNDY® TUBING COMPANY**

HOMETOWN, PA. • DETROIT 14, MICH. • WINCHESTER, KY.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, ITALY, JAPAN





Courtesy R. T. French Co. and Pneumatic Scale Corp. Ltd.

With the flexible sureness of human hands, parallel rubber tubes on this automated machine carry mustard jars through cleaning process in one of R. T. French's modern plants.

## Pneumatic Rubber Tubes Solve Delicate Handling Problem

Guided by two large pulleys a pair of lightly inflated rubber tubes pick up glass jars from a flat conveyor at the rate of 240 per minute. With a cushion grip that conforms to these irregularly shaped containers the rubber tubes invert the jars and, without ever dropping one, carry them over jets of 60-psi air for scrupulous cleaning.

The success of this unique device depends on ability of the tubes to hold each jar with uniform, safe tension. To do this, the rubber tubes must retain their given size, shape and resilience while constantly stretching and flexing. Superior impermeability is also essential to prevent any dissipation of air even after long periods of use. Furthermore, the tubes must not kink or collapse when taking relatively sharp turns, especially with the thin tube wall and large cross section.

To save the customer extra equipment costs, the "stretch" of the compound was prefigured so that the manufacturing size would inflate to the proper working size without adjustments.

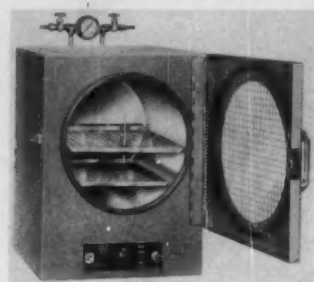
These exacting specifications require a precise blend of synthetics, processed and cured with the expert techniques of rubber specialists to assure a practical, functional rubber compound of exceptionally long working life.

This is another example of the complete engineering, laboratory and manufacturing service given to rubber parts produced by Continental. Next time your product calls for rubber parts, consult Continental—use this specialized help to save both tooling and material costs and still get rubber components that are practical, functional and dependable.

*Another achievement in* **RUBBER**  
 *engineered by* **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

## ENGINEERING DEPT. EQUIPMENT



ers to take up space. Oven heats from room to 500 F in one hour with temperature uniformity maintained within  $\pm 1$  F at all settings. Safety-glass window in the door permits full view of contents. Spring-type hinge keeps door closed even without vacuum. **Labline Inc.**, 3070-82 W. Grand Ave., Chicago 22, Ill.

Circle 782 on Page 19

## Portable Tape Recorder

has six tape speeds  
from  $1\frac{7}{8}$  to 60 ips

Portable magnetic tape recorder CP-100 is a complete 7 or 14-channel recording and reproducing system. It is a reliable reel-to-reel machine for instrumentation or general laboratory application. Providing extremely precise performance, unit can be operated in mobile case or mounted in a standard 19-in. equipment rack. It accommodates either

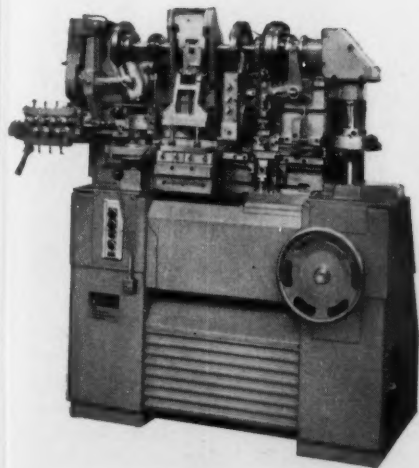


$\frac{1}{2}$  or 1-in. wide tape on  $10\frac{1}{2}$ -in. reels, and provides six tape speeds from  $1\frac{7}{8}$  to 60 ips as well as fast-forward and rewind. Built for use at altitudes to 10,000 ft, CP-100 operates while in motion in airplanes, surface ships, trailers, submarines, and other mobile applications. Either 28-v dc or 115-v ac, 60 or 400-cps power can be used. **Ampex Data Products Co.**, Dept. 511-1, 934 Charter St., Redwood City, Calif.

Circle 783 on Page 19



## PROFIT-TREE!



These are formed parts produced in single automatic operations on the revolutionary new Torrington Vertical 4-Slide.

With precision and speed, the Verti-Slide has replaced as many as five and six progressively tooled presses in the production of a complex part. Normal secondary operations such as welding are being done in one continuous automatic operation in excess of 100 pcs/min.

If you make or buy complex wire or strip parts, the Verti-Slide method offers dramatic reductions in production cost. Less parts handling, in process inventory, machine space—all mean greater profits to you.

Write or call for field technical data or a Torrington Sales Engineer.

**MACHINE DIVISION** Torrington, Connecticut  
Circle 583 on Page 19

**THE TORRINGTON MANUFACTURING COMPANY**

# MATED PARTS help new pen

another  
wonderful  
**GRC**  
idea  
for designers

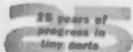


8 tiny parts die cast & molded by GRC for Esterbrook . . . precision "mated" to solve the intricate parts problem posed by new-type ballpoint pen

GRC molded 4 tiny parts in nylon and die cast 2 in zinc alloy to form the foundation of the new rotating mechanism evolved by Esterbrook engineers. The uniformity and accuracy of GRC's unique automatic single cavity die casting and molding methods made possible the precision mating of tiny parts . . . eliminated the necessity of selective assembly . . . assured trouble-free operation of the assembled pen . . . and again provided a new dimension to designers faced with a difficult situation.



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Circle 584 on Page 19

## THE ENGINEER'S Library

### Recent Books

**Basic Graphical Kinematics.** By Harold B. Kepler, assistant professor of mechanical engineering, Air Force Institute of Technology; 314 pages, 5 3/4 by 8 1/4 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from MACHINE DESIGN, \$6.00 per copy postpaid.

Graphical approach is employed to analyze the traditional topics of kinematics. Displacements, velocities, accelerations, cams, gears, chains, and belts are covered. Knowledge of calculus is not necessary to understand the material.

Equivalent-linkage concept is discussed to simplify the analysis of mechanisms that would otherwise involve the Coriolis law. Synthesis techniques are introduced, but only in treatments of cams and gear trains.

**Analysis of Deformation—Volume Four: Waves and Vibrations.** By Keith Swain; 370 pages, 5 3/4 by 8 1/4 in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from MACHINE DESIGN, \$15.00 per copy postpaid.

Deformation theory is applied to the propagation of stress through, and on the surface of, substances possessing elasticity, plasticity, and fluidity. Available experimental evidence is examined in an attempt to support the theory.

Effect of rate of load application and reduction on the speed of wave propagation is studied. Classical analyses are presented and examined critically. In particular, the equivoluminal wave through an elastic solid is questioned.

### New Standards

**American Standard, ASA B18.2—1960, Square and Hexagon Bolts and Nuts.** 34 pages, 8 1/2 by 11 in., paperbound, stapled; published by The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; available from The

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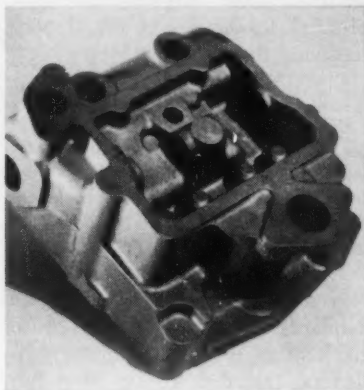



## PRODUCT-DESIGN BRIEFS FROM DUREZ

- Smooth surfaces in metal castings
- Plastic in luggage pods
- Fast facts on phenolics

### Inside story

In an engine block such as this one, smoothness of the inner surfaces is a high-priority design problem. Any obstruction or undue roughness in the channels is likely to impede the flow of coolant through the block.



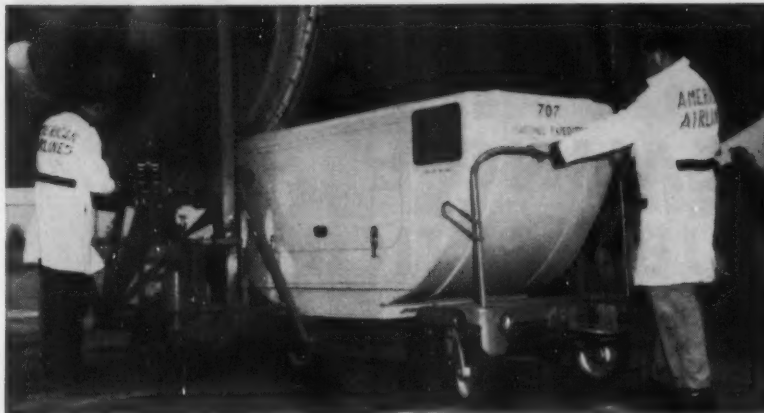
To solve the problem, more and more foundrymen are switching to a method of making castings that gives smooth, clean inner surfaces every time: shell cores.

They're getting more than smoothness. The close tolerances possible with shell cores permit holding section thickness uniform throughout the piece, and from piece to piece. In an engine block, that means better heat transfer.



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pact, heat-resistant, electrical, etc.). It lists properties of the molding compounds and of molded specimens. It tells which MIL specs a compound is designed to meet. All you do is check the coupon to get a copy free.

For more information on Durez materials mentioned above, check here:

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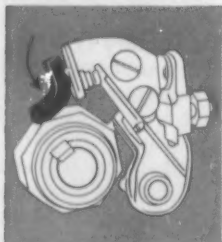




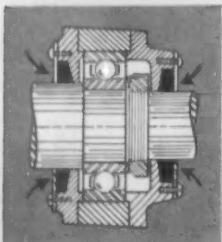
# How **FELT** BY FELTERS Can Improve Product **SEALING and LUBRICATION**



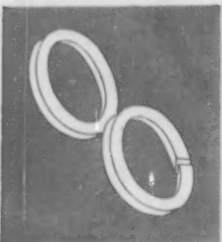
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*American Standards Association Inc., 10 East 40th St., New York 16, N. Y.; \$2.00 per copy.*

Dimensional and material specifications for square and hexagon-headed bolts and cap screws, lag bolts, square-head set screws, and nuts are covered. This latest revision makes changes in certain bolt length tolerances and contains an appendix of SAE and ASTM grade markings for steel bolts. Other appendices cover wrench openings, formulas for head and nut dimensions, and thread runout sleeve gage.

*ASTM Standards on Metallic Electrical Conductors. 368 pages, 6 by 9 in., cloth-bound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; \$4.50 per copy.*

This sixth edition supersedes the 1957 edition and contains all of the standards published by ASTM in the field of metallic electrical conductors. Included in the 59 standards are three new ones and 36 standards that were revised or have their status changed.

Among the materials covered are copper, copper alloys, copper-covered steel, aluminum, aluminum-covered steel, and galvanized steel and iron.

## Association Publications

*Rules for Alphabetical Filing. 65 pages, 8 1/2 by 11 in., paperbound, plastic-ring binder; available from Treasurer, American Records Management Assoc., 3365 Middlebury Dr., Dearborn, Mich.; \$4.00 per copy.*

After a three-year study of the problem, an ARMA committee came up with 50 rules covering recurring situations that arise in alphabetical filing. ARMA has approved these rules as a standard for office practices.

## Manufacturers' Publications

*Controlled Rectifier Manual. 255 pages, 6 by 8 1/2 in., paperbound, plastic ring binder; published by and available from General Electric Co., Dept. SCR, Charles Bldg., Liverpool, N. Y.; \$1.00 per copy.*

Detailed information about applications of silicon-controlled rectifiers is presented. Information includes intermittent loads, firing, turn-off, heatsink design, parallel-

ing, and other application problems. Also, typical basic circuits are described and discussed.

### Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

**PB 161044. Development of Low Alloy Steel Compositions Suitable for High Strength Steel Castings.** By H. R. Larson, R. C. Campbell, and H. W. Lloyd, all from American Brake Shoe Co.; 106 pages, 8 1/4 by 10 1/4 in., paperbound, stapled; \$2.50 per copy.

Alloy variations were studied to determine the best analysis for oil-quenched and tempered steels at tensile strengths from 180,000 to 300,000 psi. Results of alloys tests are tabulated and discussed.

**PB 161296. Effect of Prior Creep on Short-Time Mechanical Properties of 17-7 PH Stainless Steel—RH 950 Condition Compared to TH 1050 Condition.** By J. V. Gluck and J. W. Freeman, University of Michigan; 91 pages, 8 1/4 by 10 1/4 in., paperbound, stapled; \$2.25 per copy.

Effect of elevated-temperature creep exposure on 17-7 PH stainless steel was studied. Exposures were for 10, 50, and 100 hr without stress being applied, and at stresses causing up to two per cent creep deformation at 600 F. Test results are given in charts and tables.

**PB 161299. Electronic Designer's Shock and Vibration Guide for Aircraft Applications.** By R. E. Barbieri and W. Hall, RCA Service Co.; 260 pages, 8 1/4 by 10 1/4 in., paperbound; \$4.00 per copy.

This manual presents a general treatment of shock and vibration of electronics equipment, and covers the mechanical design of such equipment. All phases of shock and vibration applicable to airborne electronic equipment are covered.

**PB 161303. The Effects of Inelastic Action on the Resistance to Various Types of Loads of Ductile Members Made from Various Classes of Metals: Part XI—Photoelastic Analysis of I-Beams with Elliptic-Type Web Cutouts.** By Will J. Worley, University of Illinois; 27 pages, 8 1/4 by 10 1/4 in., paperbound, stapled; \$0.75 per copy.

Elastic stress distribution in the web section of I-beams with various shapes of elliptic web cutouts is investigated. Prediction of the location of the fully plastic hinges using the shear-difference method is discussed for one shape of web cutout.

**PB 161325. Preliminary Studies of Brittle Fracture Propagation in Structural Steel.** By W. J. Hall, W. G. Godden, and O. A. Fetta-Hogiu, all from University of Illinois; 90 pages, 8 by 10 1/4 in., paperbound, side-stapled; \$2.25 per copy.

Initial research work to obtain information about the crack speed and strain distribution in a mild-steel plate during brittle crack propagation is described. Initial development of test procedures, and a preliminary test program on 2-ft wide specimens of rimmed-steel plate are discussed.

**PB 161329. A Bibliography on Propagation of Sound through Plates.** By G. B. Thurston and R. Stern, University of Michigan; 170 pages, 8 by 10 1/4 in., paperbound, side-stapled; \$3.00 per copy.

Literature on the propagation of sound through plates covers the period from 1929 through 1958. Topics are divided into transmission through plates, wave propagation, properties of materials, vibrating surfaces and plates, and general references. About 450 abstracts are included.

**PB 161337. Development of High-Temperature Iron-Base Alloys.** By A. Kasak, V. K. Chandhok, and E. J. Dulla, all from Crucible Steel Co. of America; 62 pages, 8 1/4 by 10 1/4 in., paperbound, stapled; \$2.00 per copy.

Steels that have high strengths at ambient temperature and at temperatures approaching 1200 F were developed. Composition and heat treatment of the steels are discussed.

**PB 161412. Research on the Mechanisms of Fatigue.** By J. C. Grosskreutz and Fred R. Rollins, Midwest Research Institute; 64 pages, 8 1/4 by 10 1/4 in., paperbound, stapled; \$2.00 per copy.

Microphysical changes accompanying cyclic stress in copper and aluminum samples were studied by x-ray and electron-microscope techniques. Annealing effects on fatigue life were also investigated.

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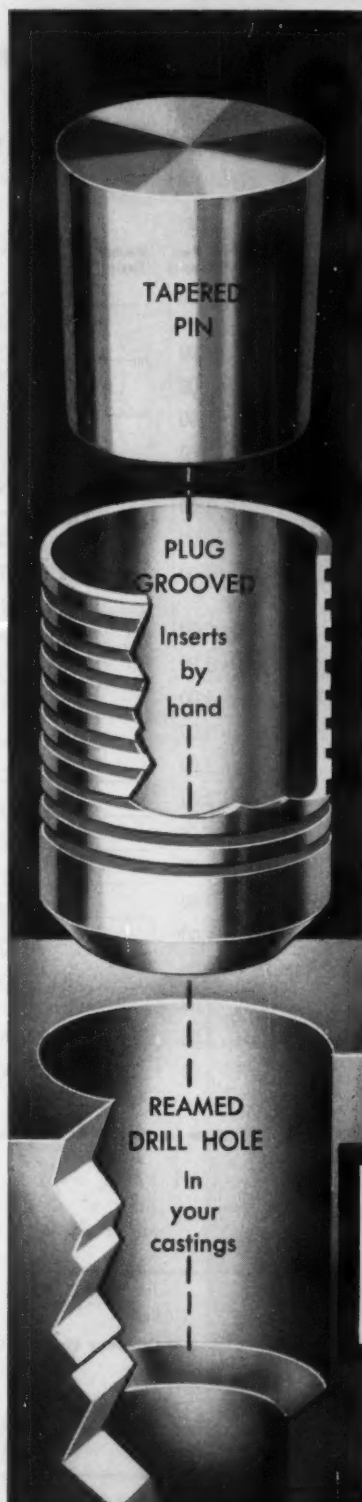
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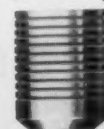
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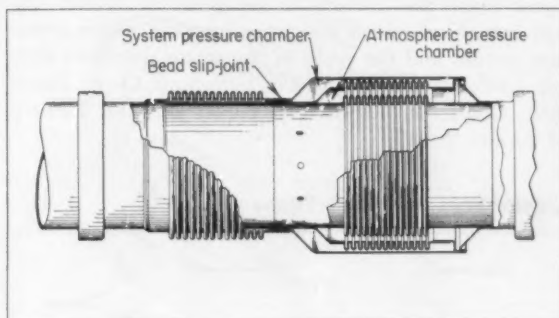


NOTEWORTHY

# Patents

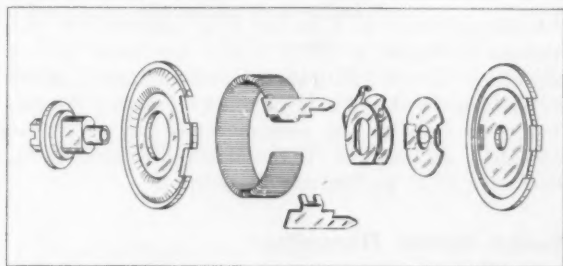
## Flexible-Duct Compensator

Axial and angular adjustment in ducting over a wide range of temperatures is provided partly by a bead-slip-joint and partly by bellows components. Pres-



sure chambers within a concentric-bellows compensator are so proportioned that axial tensile forces are maintained within the ducting regardless of the internal pressure, which may be as great as 120 psi. Temperature range is from -65 to 700 F. Patent 2,942,896 assigned to Lockheed Aircraft Corp., Burbank, Calif. by Thomas G. Hill.

## Preset Variable-Resistor Assembly



Dual-purpose parts feature the design of a preset variable resistor. Resistor elements serve also as housing or covers. Even the assembled resistor is held together by the components without the use of extra securing piece-parts. Patent 2,943,288 assigned to CTS Corp., Elkhart, Ind. by Wilbert H. Budd.

## High-Speed Small-Motor Governor

Close speed regulation of small dc motors, for either direction of rotation, is obtained by switch contacts that serve as governor fly balls. The switch contacts are spring loaded and remain in contact so long as the motor speed remains below a preset maximum. When this maximum speed is reached, centrifugal



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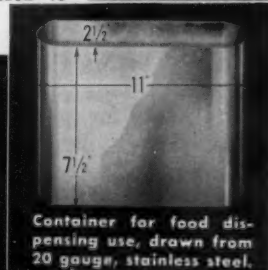
If you are working on new designs, or have run into troublesome technical problems on what you are already doing, there's a very good chance that Polar engineers and Polar facilities can give you positive help — in stainless steel, carbon steel or aluminum. Please address your inquiries to the Contract Department.



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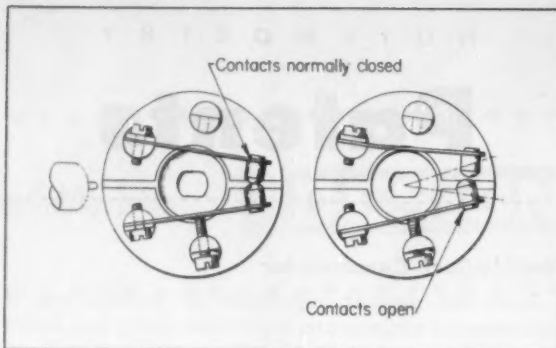
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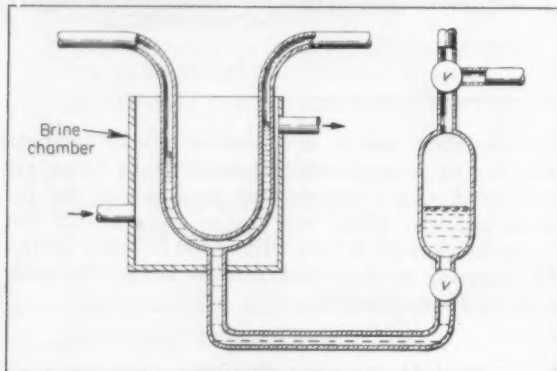
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### NOTEWORTHY PATENTS



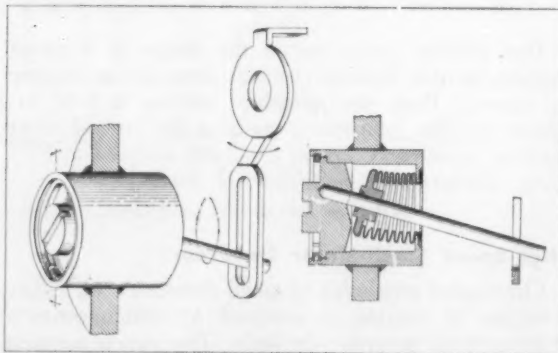
forces cause the contacts to separate, the broken circuit introduces added resistance into the motor armature circuit, and the speed of the motor decreases. *Patent 2,945,101 assigned to the Reflectone Corp., Stamford, Conn., by Kenneth J. Chichester and Edward M. Crocco.*

### Liquid Seal for High Vacuum



Gallium is used as a sealant in a high-vacuum seal, because it freezes at 29.75 C and has other sealing properties. In the illustration liquid gallium is caused to flow into or out of a U-tube trap. Freezing the gallium gives stability and permanence of sealing. *Patent 2,942,615 assigned to Consolidated Vacuum Corp., Rochester, N. Y. by Benjamin B. Dayton.*

### Sealed Motion Transmitter

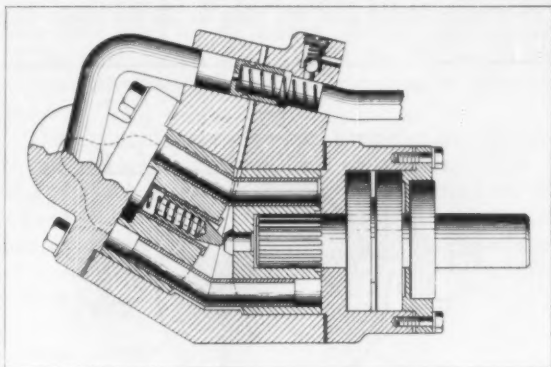


Movements to adjust an instrument within a hermetically sealed casing are made with a metallic bel-

lows assembly. The bellows is sealed to the casing at one end and to the adjustment bar at the other. Wide displacements of the bar are possible except for rotation about its own axis. Patent 2,941,407 assigned to Daystrom Inc., Murray Hill, N. J., by Paul P. Huber and Edward W. Hoyer.

### Positive-Porting Angular-Piston Pump

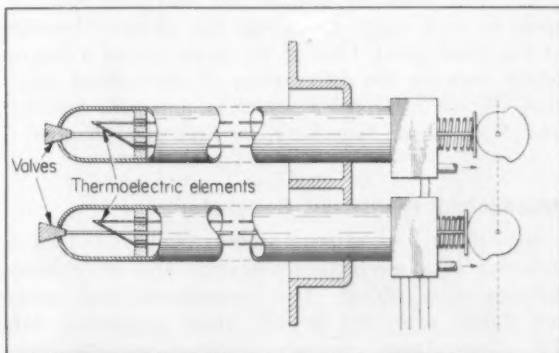
Spring-loading device between the cylinder blocks of an angular piston pump insures positive porting and priming during starting operations. In effect, the de-



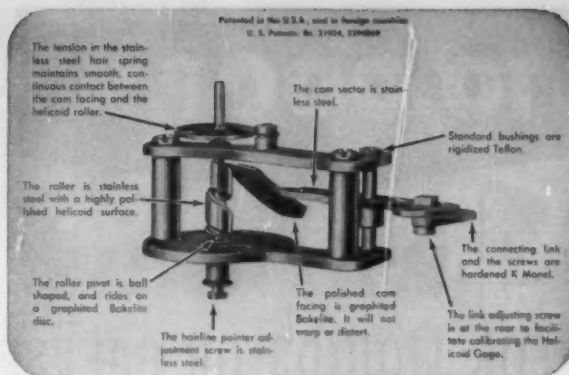
vice eliminates the normal end play of the cylinder blocks and keeps them seated against the respective end blocks during starting. As a result, liquid seals are established and normal operating pressures within the pump housing can be built up quickly. Patent 2,939,398 assigned to Thompson Ramo Wooldridge Inc. by John P. Heiss.

### Gaseous Atmosphere Analyzer

Carbon content in a gaseous atmosphere is measured and controlled by dual thermoelectric junctions or elements. One thermoelectric element is exposed



to the carbon-bearing atmosphere while the other is being defouled in a hydrogen atmosphere. Cam operated valves open the ends of tubular members to expose the elements to the atmosphere being analyzed. Carbon buildup on the exposed thermoelectric element changes its potential. The tubes are palladium and



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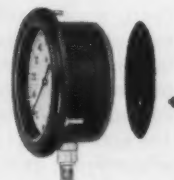
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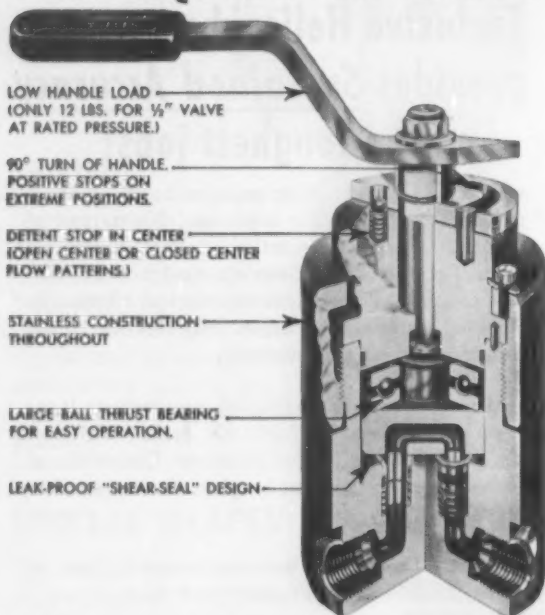
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# 10,000 P.S.I.

## 4 WAY VALVE FOR LIQUIDS OR GASES



This new four-way valve series comes in pipe sizes from  $\frac{1}{4}$  to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

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CONTROL VALVE  
DIVISION

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**Barksdale valves**

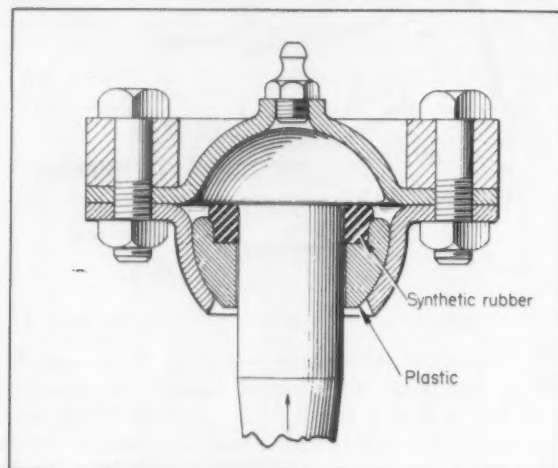
8125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

### NOTEWORTHY PATENTS

porous to hydrogen. Hence, when a valve is closed, only hydrogen surrounds the isolated thermoelectric element. The potentials of the fouled and defouled elements are added electrically for the resultant control signal. *Patent 2,941,395 assigned to Minneapolis-Honeywell Regulator Co., Minneapolis, by Jay Leland Myer.*

#### Preloaded Ball Joint

Semiresilient plastic of a self lubricating type and a resilient, though incompressible, substance such as synthetic rubber maintain the preload on a ball joint. Lubricant is forced into the joint to fill the voids. The



plastic member seals the joint and tends to retain the lubricant under pressure. *Patent 2,942,901 assigned to Thompson Ramo Wooldridge Inc. by James H. Booth.*

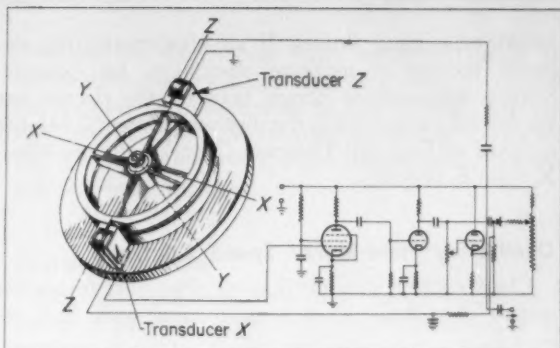
Dual-range extensometer provides magnification of strains within the elastic range of the test specimen and direct measurement of strains beyond the yield point. Two arms are pivoted and fulcrumed with respect to each other to change the effective leverage at the yield point. One of the arms carries a pickup which registers the deformation of the stressed specimen. *Patent 2,941,298 assigned to American Machine and Metals Inc., New York, by Francis C. Huyser.*

#### Mechanical Frequency Generator

Insensitivity to external shocks and vibrations is achieved in a mechanical vibratory unit by dynamic balance in all planes. Two nonmagnetic ring masses are rigidly supported by ribs about a common axis, YY. They vibrate circumferentially in opposite directions in response to alternating current in electromagnetic transducers X and Z.

External shocks and vibrations in the XX direction have little influence on the output signal induced by the Z transducer. Similarly, the output signal resulting from the X transducer is not influenced appreciably by shocks in the ZZ direction. The ribs are so shaped



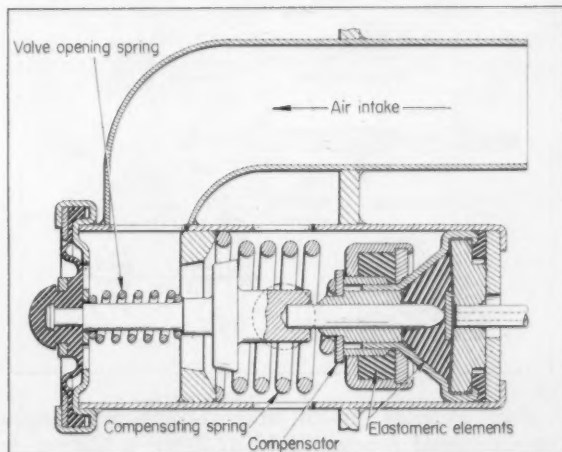


that rotational shocks about either the XX or ZZ axes have little effect on the masses. Hence, the frequency of the final output signal about the YY axis is the natural frequency of angular vibrations of the ring masses.

The electronic control system comprises an amplifier circuit connected between the pickup transducer X and the drive transducer Z. The components are selected so as to drive the mechanical system at its natural resonant frequency. *Patent 2,939,971 assigned to the Gyrex Corp., Santa Monica, Calif., by William J. Holt Jr.*

Air-operated control systems are transferred immediately from automatic to manual control and vice versa chiefly with interlocked independent systems. Transmitter-receivers and feedback connections keep one system essentially in step with the other. The air-control arrangement is similar when the system is used to control a process by either a valve, a motor, or some other unit. *Patent 2,939,472 assigned to Minneapolis-Honeywell Regulator Co., Minneapolis, by Harold E. Eller.*

#### Compensated Valve-Actuator Assembly



A spring-loaded compensator allows relief expansion and contraction to accommodate malfunctioning of valve-control elements as a consequence of absorption of moisture, excessive pressures, and abnormal variations in temperature. Axial adjustment takes place be-

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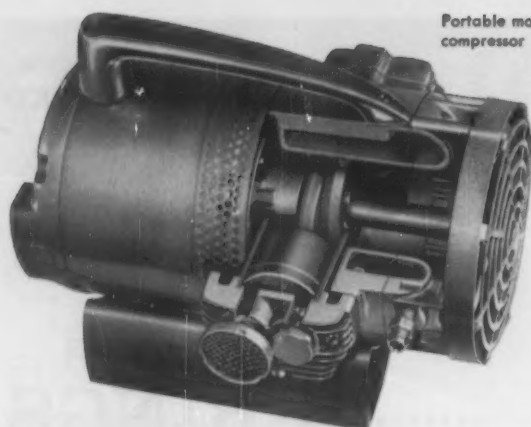
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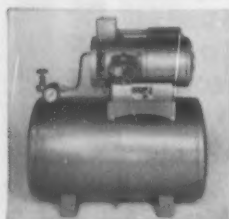
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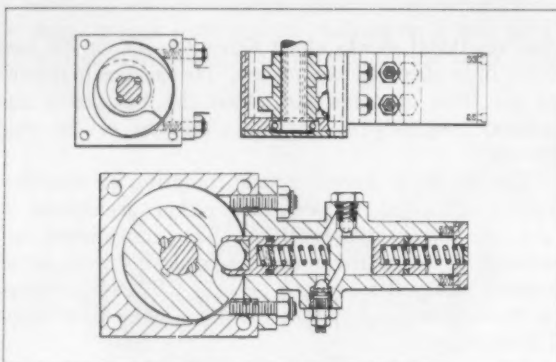
BELL & GOSSETT COMPANY  
Dept. GH-67, Merton Grove, Illinois

## NOTEWORTHY PATENTS

tween telescoping sleeves. If an elastomeric ring expands because of moisture absorption, for example, relative displacement occurs between the sleeves but the central control pin is not displaced. *Patent 2,941,404 assigned to Standard-Thomson Corp., Waltham, Mass. by John E. Woods.*

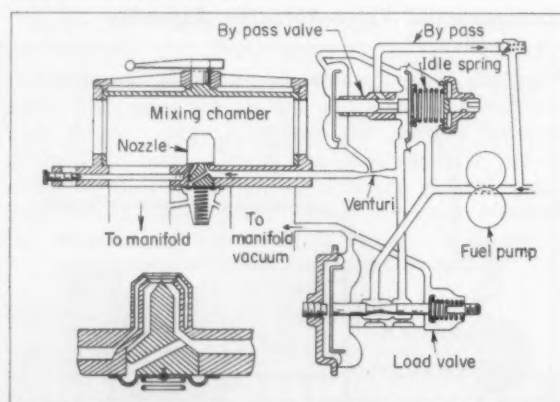
## Oscillating Fluid-Motor Speed Control

Close control over oscillatory, fractional-revolution motion of a fluid motor is maintained with dual as-



semblies of cams, pistons, cylinders, and dashpots. The angular cam displacements which control opposite directions of rotor motion may be equal or unequal. During a displacement in either direction, a cam causes its associated piston and cylinder to displace a quantity of fluid in proportion to cam geometry and angular travel. Reversal occurs when the pressure is built up to a predetermined value. *Patent 2,941,513 assigned to Roto-Tork Mfg. Co. by Edward F. Paulus.*

## Pressure Carburetor

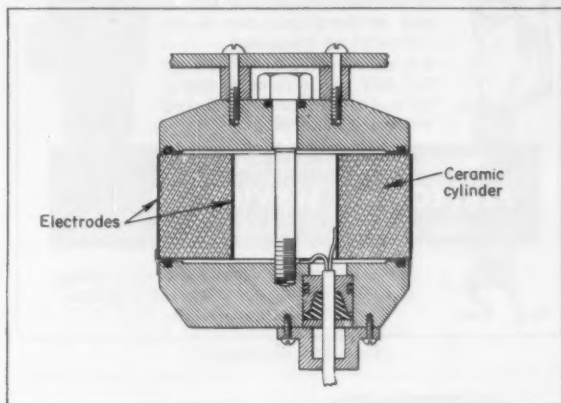


Fuel metering to an internal-combustion engine at a manifold pressure of 15 to 20 psi is attained by controlling the pressure drop across a load valve. This pressure drop is a function of engine speed and manifold pressure or engine load. An increase in pressure drop across the load valve tends to close a by-pass valve, thereby forcing more fuel through the venturi to the engine. The differential pressure at the venturi

also acts on the by-pass valve in opposition to the differential pressure across the load valve to regulate the by-pass valve according to flow through the venturi. Patent 2,944,537 assigned to Holley Carburetor Co., Detroit, by George B. Stroh, Raymond L. Ensinger, and Warren H. Cowles.

### Energy Converter

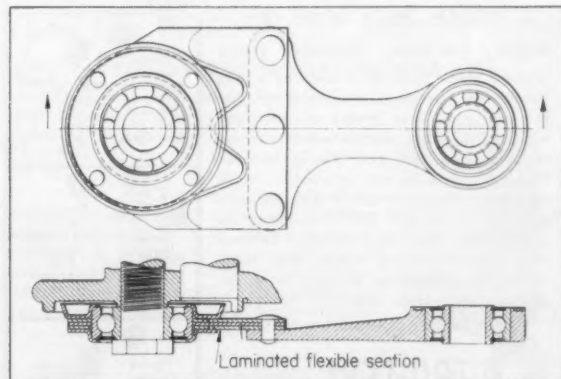
Conversion of high-frequency, compressional wave energy into electrical energy, and vice versa, is accomplished by a ferroelectric ceramic cylinder. The electrodes are film coatings on the inside and outside of the ceramic cylinder. The cylinder is activated and vibrates radially when a voltage is applied to the elec-



trodes. Only the outer film coating is exposed to the compressional wave medium. Patent 2,945,208 assigned to General Electric Co. by Richard W. Samsel.

### High-Speed Ball-Bearing Pitman

A short laminated assembly in a pitman provides lateral flexibility without sacrifice in column rigidity. A main leaf in the sandwich assembly transfers the tension forces. The side leaves abut each other along scalloped contours for transverse rigidity and to trans-



fer compressive forces. Patent 2,941,419 assigned to Allis-Chalmers Mfg. Co., Milwaukee, by Rector C. Ferguson.

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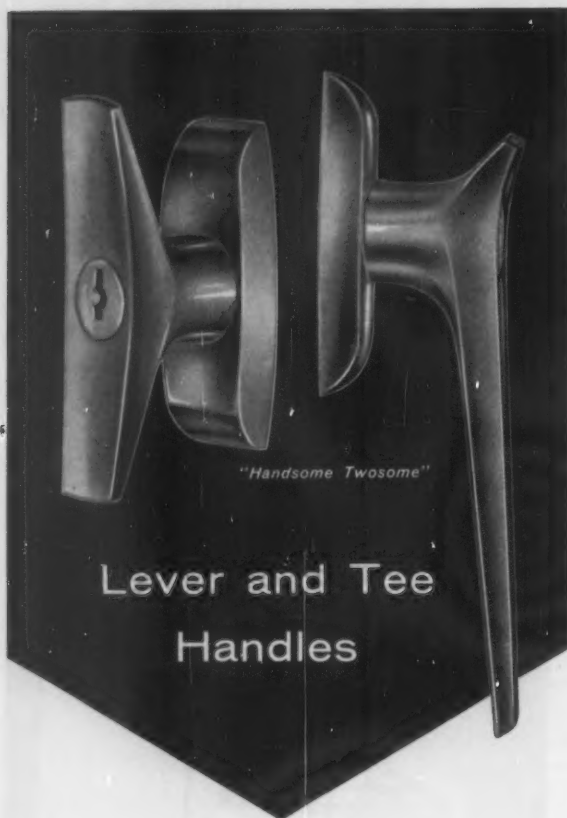
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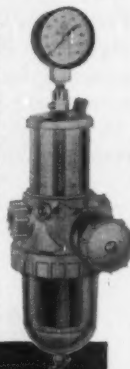
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Circle 598 on Page 19



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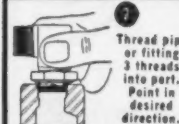
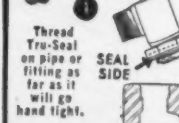
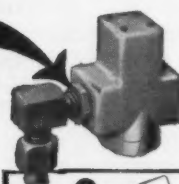


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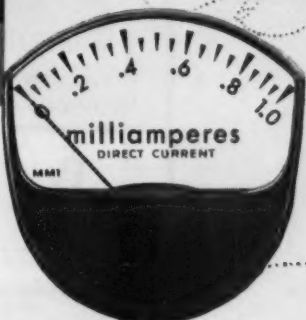
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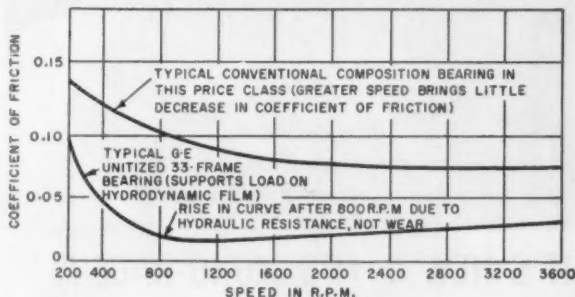


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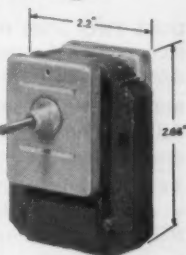
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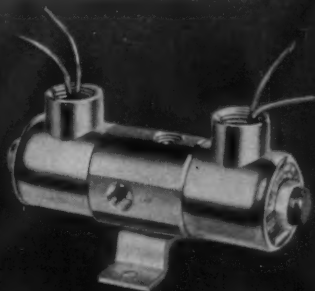
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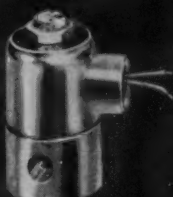
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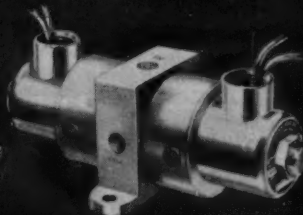


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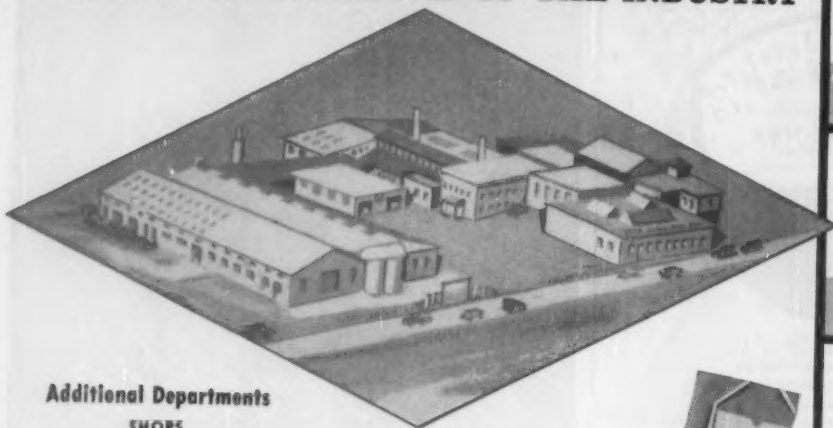
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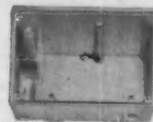
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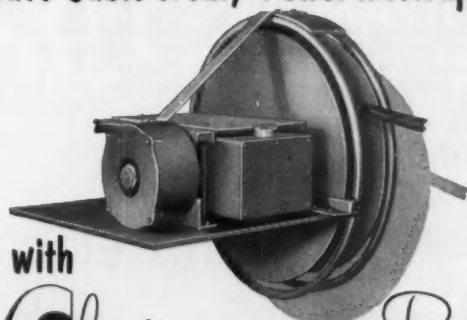
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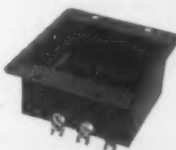


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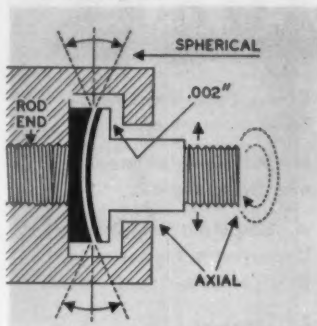
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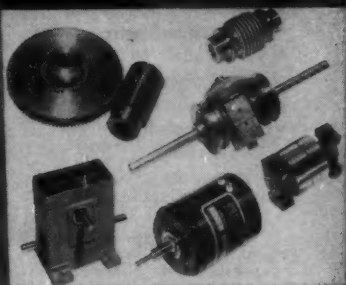
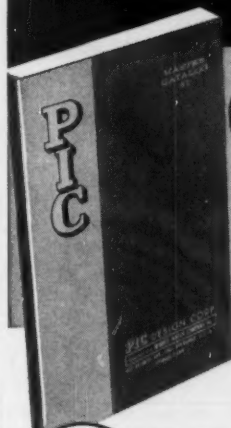
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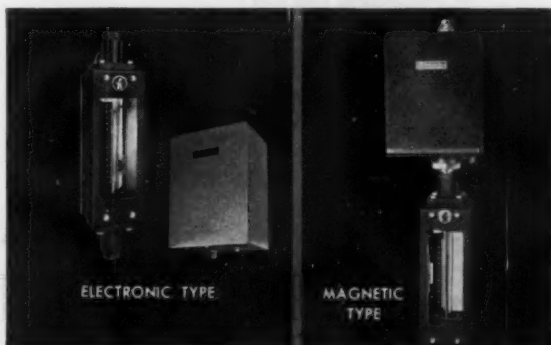
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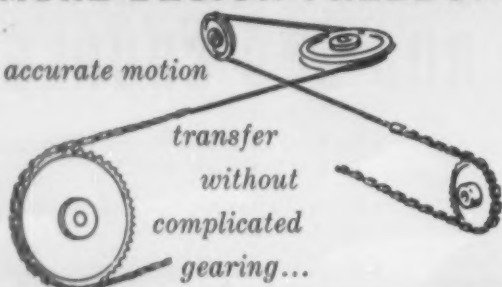
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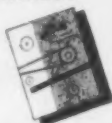
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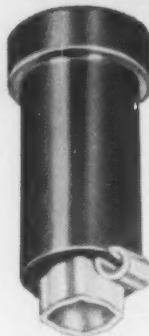
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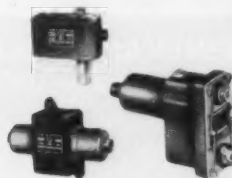
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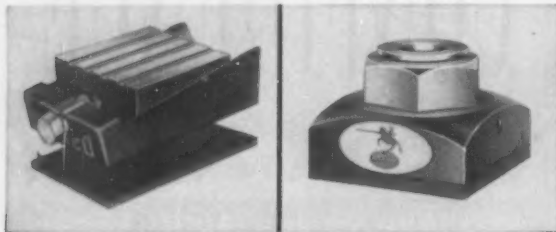


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## Advertising Index

Acheson Colloids Co., A Division of Acheson Industries, Inc.	219
Airmatic Valve, Inc.	289
Alco Products, Inc.	244
Alkon Products Corporation	56
Allis, Louis, Co., The	52, 53
Aluminum Company of America	125
American Brass Co., The, Anaconda Metal Hose Division	5
American Chain & Cable Co., Inc.	287
American Chain & Cable Co., Inc., Helicoid Gage Division	283
American Hardware Corporation, The, Corbin Cabinet Lock Division	288
American Machine & Foundry Co., Potter & Brumfield Division	193
American Machine and Metals, Inc., Hunter Spring Co. Division	65, 66
American Society for Metals	240
Anaconda Metal Hose Division, The American Brass Co.	5
Anker-Holth Division, The McDowell-Wellman Companies	80
Apex Machine & Tool Co., The	253
Armstrong Cork Co.	2
Associated Spring Corporation	112
Associated Spring of Puerto Rico, Inc.	112
Auburn Manufacturing Co., The	291
Automatic Electric	116
Automatic Timing & Controls, Inc.	270
Barksdale Valves, Control Valve Division	284
Barnes, Wallace, Co., The, Ltd., Division of Associated Spring Corporation	112
Barnes, Wallace, Division, Associated Spring Corporation	112
Barnes, Wallace, Steel Division, Associated Spring Corporation	112
Bausch & Lomb	296
Bell & Gossett Co.	286
Bendix Corporation, The	291
Benton Harbor Engineering Works, Inc.	268
B-G-R Division, Associated Spring Corporation	112
Boots Corporation	272
Borg-Warner Corporation, Rockford Clutch Division	218
Bound Brook Oil-less Bearing Co.	Inside Front Cover
Bridgeport Brass Co., Cored Forging Division	231
Bridgeport Thermostat Division, Robertshaw-Fulton Controls Co.	48, 49
Brown & Sharpe Mfg. Co., Hydraulics Division	202
Bruning, Charles, Co., Inc.	197
Buffalo Forge Co., Air Handling Division	35
Bundy Tubing Co.	273
Carlson, G. O., Inc.	29
Chain Belt Co.	209, 211, 213, 215
Chicago Rawhide Manufacturing Co., Sirvis Division	Back Cover
Chiksan Co.	132, 133
Cinch Manufacturing Co., Howard B. Jones Division	292
Clearprint Paper Co.	103
Cleveland Worm & Gear Division, Eaton Manufacturing Co.	Inside Back Cover
Commercial Shearing & Stamping Co.	225
Cone-Drive Gears Division, Michigan Tool Co.	88, 89
Continental Rubber Works	274
Corbin Cabinet Lock Division, The American Hardware Corporation	288
Crane Packing Co.	44
Cutler-Hammer, Inc.	120, 121

Dana Corporation	69
De Laval Steam Turbine Co.	98, 99
Diamond Alkali Co.	67
Diamond Chain Co., Inc.	229
Dixon Corporation	251
Dodge Manufacturing Corporation	72, 73
Dallin Corporation	295
Dow Corning Corporation	37, 38
Drop Forging Association	212
Dunbar Brothers Division, Associated Spring Corporation	112
Du Pont, E. I., de Nemours & Co., Inc.	59, 60, 113
Durez Plastics Division, Hooker Chemical Corporation	277
Eagle Picher Co., The, The Ohio Rubber Co. Division	102
Eagle Signal Co.	208
Eastman Chemical Products, Inc., Chemicals Division	239
Eastman Manufacturing Co.	90
Eaton Manufacturing Co., Cleveland Worm & Gear Division	Inside Back Cover
Edwards Co., Inc.	45
Elgin National Watch Co., Abrasives Division	203
Enjay Chemical Co., A Division of Humble Oil & Refining Co.	108, 109
Enterprise Machine Parts Corporation, The	296
Fairbanks, Morse & Co., Electrical Division	57
Fairchild Engine & Airplane Corporation, Stratos Division	258
Farrel-Birmingham Co., Inc.	200
Federal-Magul-Bower Bearings, Inc., National Seal Division	122
Fellows Gear Shaper Co., The	128
Felters Co., The	278
Ferguson Machine Corporation	33
Flick-Ready Corporation, Miller Fluid Power Division	117
Flick-Ready Corporation, Tru-Seal Division	288
Foots Bros. Gear and Machine Corporation	106, 107
Formica Corporation	217
Farmsprag Co.	130, 131
Gamble Brothers, Inc.	246
Gardner-Denver Co.	134
Gast Manufacturing Corporation	205
Gates Rubber Co., The	78
General Aniline & Film Corporation, Oxalid Division	188
General Electric Co.	40, 41, 62, 63, 85, 86, 126, 127, 260, 261, 289
General Motors Corporation, Hyatt Bearings Division	94, 95
General Motors Corporation, New Departure Division	11
Gibson Division, Associated Spring Corporation	112
Gits Bros. Mfg. Co.	223
Gleason Reel Corporation	291
Gleason Works	123
Globe Industries, Inc.	259
Goodrich, B. F., Co., The, Aviation Products Division	16
Goshen Rubber Co., Inc.	285
Gray Iron Founders' Society, Inc.	257
Gray Tool Co., Grayloc Sales Division	242
Gries Reproducer Corporation	276
Haloid Xerox, Inc.	118
Hamilton Foundry, Inc.	51

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# backtalk—

## —Opus, No. 1

The new MACHINE DESIGN feature "Engineer at Work," which begins on Page 26 of this issue, will prove that engineering is not all slide rules and Greek symbols. Articles in this intermittent series will discuss an engineering project and give a brief account of the man assigned to the job.

While we recognize that Giff Bull, engineering pilot, is a glamour boy among engineers, we are also sure that a fair number of MACHINE DESIGN readers do work that would be of more than passing interest to the rest of us. If you or the fellow at the next desk has an interesting job, we'd like to hear about it—and maybe immortalize it in print.

## —Man behind the News



Associate editor Bill Miller, who masterminds MACHINE DESIGN's Engineering News department, is currently touring the West Coast to dig up facts for features. Bill will be in his element when visiting the many aircraft plants—he has been a wild-blue-yonder fan since the "rag-wing" days. He studied mechanical engineering at Delaware University, then went on to earn a master's degree in aeronautical engineering at Cornell. Next came a job at the Lewis Flight Propulsion Lab, NACA. He

advanced to group leader in research instrumentation and was doing power-plant research when he came to MACHINE DESIGN in 1956.

Bill's (you should excuse the expression) long-hair achievements include election to Tau Beta Pi, Phi Kappa Phi, and Sigma Xi. He is a member of the Institute of Aeronautical Sciences and is chairman of the Machine Design Division of the Cleveland Engineering Society.

Bill served as an aircraft engineering officer in the Army Air Corps during World War II. They wouldn't let him fly though (some business about not being able to tell tuchsia from chartreuse), so he waited until the war ended, then dug out his private-plane license and went up whenever he had the price of an hour's flying time.

At home on land and in the air, Bill has now set out to conquer the sea. First attempts have been in the waters of Lake Erie in a 16-ft Millercraft (built in the basement).

## —The State of One Union

An item in the Engineering News section of our July 21 issue, dealing with professionalism and "rhubarb" on unionism, turned out to be aptly titled—shortly after the issue came out, we were stewing in our own rhubarb. Unwittingly stuffing the ballot box, we reported that "nearly 1000" union members at Sperry Gyroscope had voted to affiliate with AFL-CIO. Actually, two ballots resulted in counts of 435 to 258 and 393 to 274 for affiliation.

While talking with the Sperry engineer who corrected our figures, we inquired if he is against unions. No, he told us, he is against affiliation. He also pointed out that the small number of votes suggests that most Sperry Engineers Association members (about 1400) are not for affiliation. Furthermore, another group is opposing SEA; as soon as it becomes certified, the new union hopes to oust the present one, with its "unwholesome" affiliation.

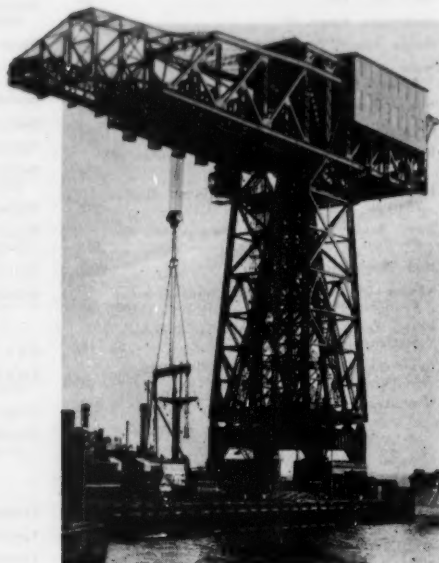
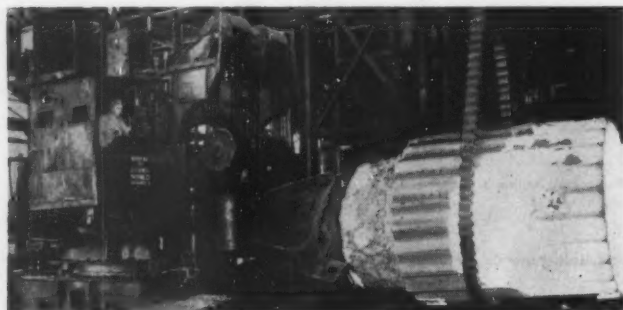
# Advertising Index

Hampden Brass & Aluminum Co. ....	290	Milwaukee Division, Associated Spring Corporation .....	112	South Chester Corporation, Southco Division ..	87
Hanna Engineering Works .....	221	Miniature Precision Bearings, Inc. ....	198, 249	S-P Manufacturing Corporation, The .....	50
Harrington & King Perforating Co., Inc., The ..	269	Minneapolis-Honeywell Regulator Co. ....	79	Spectral Electronics Corporation .....	244
Hart Manufacturing Co., The .....	216	Minneapolis-Honeywell Regulator Co., Marion Instrument Division .....	289	Speedway Mfg. Co., Division of Thor Power Tool Co. ....	292
Hayden, A. W., Co., The .....	263	Minnesota Mining and Manufacturing Co., Adhesives, Coatings and Sealers Division ..	42, 43	Sperry Rand Corporation, Vickers, Inc., Mobile Hydraulics Division .....	71
Heim Co., The .....	84	Morse Chain Co., A Borg-Warner Industry ..	114, 115	Stackpole Carbon Co. ....	195
Heinemann Electric Co. ....	91			Standard Pressed Steel Co., Industrial Fastener Division .....	58
Heinze Electric Co. ....	220			Standard Screw Co. ....	61
Helicoid Gage Division, American Chain & Cable Co., Inc. ....	283	National Lock Washer Co., The .....	196	Stanpat Co. ....	194
Hexcel Products, Inc. ....	68	National Malleable and Steel Castings Co. ..	271	Stearns Electric Corporation .....	295
Hitchiner Manufacturing Co., Inc. ....	194	National Screw & Mfg. Co., The .....	250	Stewart-Warner Corporation, John W. Hobbs Division .....	276
Hobbs, John W., Corporation, A Division of Stewart-Warner Corporation .....	276	National Seal Division, Federal-Mogul-Bower Bearings, Inc. ....	122	Stratoflex, Inc. ....	224
Hooker Chemical Corporation, Durez Plastics Division .....	277	National Vulcanized Fibre Co. ....	238, 239	Stratos, A Division of Fairchild Engine & Airplane Corporation .....	258
Howe Sound Co., Quaker State Metals Co. Division .....	255	New Departure Division, General Motors Corporation .....	11		
Huck Manufacturing Co. ....	233	New Hampshire Ball Bearings, Inc. ....	64		
Humble Oil & Refining Co., Enjay Chemical Co. Division .....	108, 109	Nylogrip Products .....	220		
Hunter Spring Co., A Division of American Machine and Metals, Inc. ....	65, 66			Taylor Fibre Co. ....	70
Hyatt Bearings Division, General Motors Corporation .....	94, 95	Ohio Division, Associated Spring Corporation ..	112	Textron Electronics, Inc., MB Electronics Division .....	247
Hydro-Line Manufacturing Co. ....	293	Ohio Rubber Co., The, A Division of the Eagle Picher Co. ....	102	Thew Shovel Co., The, Mono Race Division ..	290
		Oilgear Co., The .....	7	Thor Power Tool Co., Speedway Mfg. Co. Division .....	292
		Ozolid, A Division of General Aniline & Film Corp. ....	188	Timken Roller Bearing Co., The, Steel and Tube Division .....	21
Imperial Brass Manufacturing Co., The ....	245			Tinnerman Products, Inc. ....	136
Imperial Electric Co. ....	222	Peerless Electric Division, H. K. Porter Co., Inc. ....	199	Torrington Co., The .....	13
International Nickel Co., Inc. ....	93	Perfecting Service Co. ....	288	Torrington Manufacturing Co., The, Machine Division .....	275
		Phoenix Electric Manufacturing Co. ....	294	Townsend Co. ....	237
Jenkins Bros. ....	135	PIC Design Corporation .....	293	Transmission and Axle Division, Rockwell-Standard Corporation .....	81
Johnson Bronze Co. ....	119	Polar Ware Co. ....	281	Triangle Manufacturing Co. ....	290
Jones, Howard B., Division, Cinch Manufacturing Corporation .....	292	Polymer Corporation of Pennsylvania, The ..	228	Tru-Seal Division, Flick-Reedy Corporation ....	288
Jones & Laughlin Steel Corporation, Electricweld Tube Division .....	97	Porter, H. K., Co., Inc., Peerless Electric Division .....	199	Tuthill Pump Co. ....	191
Jay Manufacturing Co. ....	110	Porter, H. K., Co., Inc., Riverside-Alloy Metal Division .....	248		
		Post, Frederick, Co. ....	15	Uniform Tubes, Inc. ....	236
Lamb Electric Co., The .....	265	Potter & Brumfield, Division of American Machine & Foundry Co. ....	193	Union Carbide Corporation, Linde Division ..	234, 235
Lear, Electro-Mechanical Division .....	196	Precision Tube Co., Inc. ....	240	Union Carbide Corporation, Union Carbide Plastics Co. Division .....	54, 55
Lee Co., The .....	279			United Electric Controls Co. ....	295
Linde Co., Division of Union Carbide Corporation .....	234, 235	Quaker State Metals Co., A Division of Howe Sound Co. ....	255	United States Graphite Co., The, Division of The Wickes Corporation .....	76, 77
Ling Electronics, A Division of Ling-Temco Electronics, Inc. ....	206, 207			United States Rubber, Mechanical Goods Division .....	187
Link-Belt Co. ....	9, 75				
Locke Steel Chain Co., The .....	292	Raymond Manufacturing Division, Associated Spring Corporation .....	112	Valley Electric Corporation .....	254
Lord Manufacturing Co. ....	226	Reliance Electric and Engineering Co. ....	111, 256	Vickers, Inc., Division of Sperry Rand Corporation, Mobile Hydraulics Division ..	71
		Renbrandt, Inc. ....	296	Victor Mfg. & Gasket Co. ....	92
McDowell-Wellman Companies, The, Anker-Holth Division .....	80	Republic Steel Corporation .....	82, 83	Vlier Engineering Corporation .....	230
		Reuland Electric Co. ....	243		
Mac-it Parts Co. ....	266	Riverside-Alloy Metal Division, H. K. Porter Co., Inc. ....	248		
Magnaflux Corporation .....	31	Robertshaw-Fulton Controls Co., Bridgeport Thermostat Division .....	48, 49	Wagner Electric Corporation .....	252
Malleable Castings Council .....	104, 105	Rockford Clutch Division, Borg-Warner Corporation .....	218	Walde Kohinoor, Inc. ....	96
Manross, F. N., and Sons Division, Associated Spring Corporation .....	112	Rockwell-Standard Corporation, Transmission and Axle Division .....	81	Waldron-Hartig Division, Midland-Ross Corporation .....	204
Marion Instrument Division, Minneapolis-Honeywell Regulator Co. ....	289	Roper Hydraulics, Inc. ....	264	Weatherhead Co., The, Fort Wayne Division ..	210
MB Electronics, A Division of Textron Electronics, Inc. ....	247	Ross Operating Valve Co. ....	1	Westinghouse Air Brake Co., Industrial Products Division .....	201
Mechanical Air Controls, Inc. ....	74	Russell, Burdall & Ward Bolt and Nut Co. ..	129	White, S. S., Industrial Division .....	124
Meehanite Metal Corporation .....	267			Whitney Chain Co., The .....	227
Merkle-Korff Gear Co. ....	216	Schrader's, A., Son, Division of Scovill Manufacturing Co., Inc. ....	232	Wickes Corporation, The, The United States Graphite Co. Division .....	76, 77
Messinger Bearings, Inc. ....	300	Schutte and Koerting Co., Instrument Division ..	293	Wyman-Gordon .....	100, 101
Metallurgical Products Department of General Electric Co. ....	241	Scovill Manufacturing Co., Inc., A. Schrader's Son Division .....	232		
Michigan Tool Co., Cone-Drive Gears Division .....	88, 89	Seaboard Pacific Division, Associated Spring Corporation .....	112	Yardley Plastics Co. ....	282
Midland-Ross Corporation, Waldron-Hartig Division .....	204	Sierra Engineering Co. ....	294	Zipper tubing Co., The .....	258
Miller Fluid Power, Division of Flick-Reedy Corporation .....	117	Slip Ring Company of America .....	236		
		Smith, A. O., Corporation .....	46, 47	Engineers Available or Wanted .....	296

# *Time is No Threat... to the Precision Performance of* **MESSINGER BEARINGS**

**AFTER 40 YEARS** the Messinger Roller Bearing carrying a thrust load of 6,000,000 lbs. in this 350-Ton Crane (right) at the Philadelphia Naval Shipyard, is still demonstrating the enduring efficiency of Messinger design and construction.

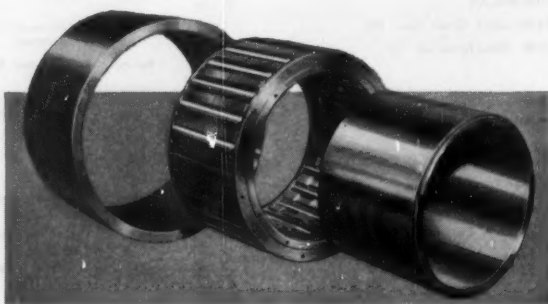
**AFTER 15 YEARS** the large Messinger "X" Roller Bearing in the heavy-duty Forging Manipulator shown below was still providing the smooth, trouble-free performance for which it was designed.



During nearly half a century, Messinger Roller Bearings have established an unequalled reputation for long, trouble-free service in continuous operation under heaviest loads. The two installations described here are typical of many in which Messinger Bearings of all sizes are still on the job after ten, twenty, thirty years or longer.

Among the factors contributing to these results are specialized design experience; the use of our own special-analysis through-hardening steel; and machine work of superlative precision.

Another important reason for the long-life efficiency of every Messinger Bearing, especially at sustained high speeds, is the cage... of highest quality bronze; machined all over with exacting care; with all dimensions held to amazingly close tolerances.



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## a rugged Cleveland Speed Variator keeps Steel Lath quality at top level

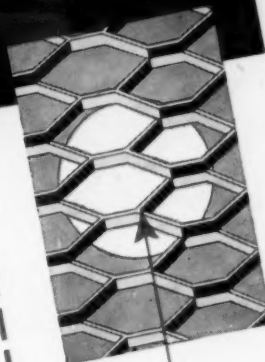
Playing an important role in the production of perforated metal lath is a heavy-duty Cleveland Speed Variator. This novel lathing "keys for keeps" because applied plaster is automatically guided into a positive locked-in position by the precise twist \* engineered into the work.

Driving the lath machine's leveller is the job assigned to the Speed Variator. It's a mighty important function because leveller speed has to be in absolute synchronization with expander speed. If not, lath will buckle or expand too much. Then lath is rejected—profits drop.

With their Cleveland Speed Variator, the lath producer is able to maintain set speeds—without any variance. Changing speeds, if desired, is merely a simple twist-of-the-wrist.

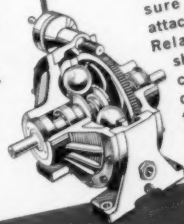
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**Cleveland Worm & Gear Division**  
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### HOW IT WORKS

Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. Relative speeds of the shafts are adjusted by changing the positioning of the axles on which the balls rotate (see cutaway view.)



**CLEVELAND**  
**SPEED VARIATOR**





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